Inflation Risk in Corporate Bonds

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ABSTRACT

We argue that corporate bond yields reflect fears of debt deflation. When debt is nominal, unexpectedly low inflation increases real liabilities and default risk. In a real business cycle model with optimal but infrequent capital structure choice, more uncertain or pro-cyclical inflation leads to quantitatively important increases in corporate log yields in excess of default-free log yields. A panel of credit spread indexes from six developed countries shows that credit spreads rise by 14 basis points if inflation volatility or the inflation-stock correlation increases by one standard deviation.

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Corporate and sovereign bonds in developed countries are overwhelmingly nominal. Firms are therefore exposed to the possibility of "debt deflation", when a surprise drop in inflation leads to increases in real liabilities and corporate default risk (Fisher (1933)). The literature has argued that corporate bonds price the volatility of real firm values as proxied by equity volatility (Campbell and Taksler (2003), Collin-Dufresne, Goldstein, and Martin (2001)). We find that inflation risk can explain at least as much variation in credit spreads as can equity volatility and the dividend-price ratio. In a panel of credit spread indexes from six developed countries, a one standard deviation move in either inflation volatility or the inflation-stock correlation increases credit spreads by 14 basis points (bps), relative to average credit spreads around 100 bps.

This paper identifies a new link between inflation risk and the credit component in corporate bond yields. This channel is on top of and separate from any inflation risk premia in nominal default-free bonds.[1] In contrast to corporate bonds, nominal government bonds are plausibly default-free if governments can inflate away their own debt. We argue theoretically and confirm empirically that inflation risk is priced into corporate bond log yields above and beyond its impact on nominal default-free log yields. Indeed, we find that inflation risk affects empirical credit spreads even after controlling for the term structure of nominal government log yields.

Corporate bond spreads price two types of inflation risk: inflation volatility and inflation cyclicality. First, more volatile inflation increases the ex-ante probability that firms will default due to high real liabilities. Second, when inflation and real cash flows are highly correlated, there is a risk of low inflation recessions. In this case, low real cash flows and high real liabilities tend to hit firms at the same time, and this interaction increases default rates and real investor losses. Moreover, inflation cyclicality may also increase the default risk premium in credit spreads if investors are risk averse.

[FIGURE 1 ABOUT HERE]

Figure 1A illustrates the close historical relation between time-varying inflation uncertainty and firms' cost of debt finance in the United States.[2] Figure 1B shows that the relation between the lower tail of inflation uncertainty and credit spreads is even stronger, consistent with our intuition that lower than expected inflation raises credit risk. In Section III of this paper, we confirm the relation between credit spreads and inflation uncertainty in a panel of six developed countries, controlling for proxies for business conditions, real uncertainty, and time-varying risk aversion.

It might at first seem surprising that the risk of debt deflation should have been salient during the high inflation 1970s and 1980s. However, debt deflation can occur whenever inflation is lower than expected, even if the level of inflation remains high. In 1982, the *New York Times* argued: "Among those most distressed by slowing inflation are individuals and businesses that took out large loans in the past few years based on the assumption that inflation would remain at very high levels. ...The farmer's new, expensively financed machinery is harvesting crops fetching lower market prices."[3]

Not only inflation volatility but also inflation cyclicality have varied over time in the U.S. Moreover, high inflation cyclicality can rationalize investors' recent relative reluctance to hold corporate bonds. When inflation dropped to extremely low levels during the financial crisis, our measure of inflation pro-cyclicality—the inflation-stock correlation—reached a peak and captured significant public concerns about debt deflation. In contrast, investors in the 1970s feared high inflation recessions—or "stagflations"—implying countercyclical inflation.

While concerns about a deflationary drop in U.S. aggregate demand have been especially strong over the past three years, our measure suggests that they have been present since at least the early 2000s. They have also been salient, as evidenced by a widely noted 2002 speech by then-Federal Reserve Governor Ben Bernanke.[4] Concerns about debt deflation are also evident in recent news reporting. For instance, *ProQuest* reports 230 news mentions of the key word "debt deflation" versus only 132 for the keyword "stagflation" over 2000 to 2009. Internationally, the Japanese experience during the 1990s provides one of the more salient examples of recent debt deflation (Kuttner and Posen (2001)).

As of December 2010, the U.S. Baa-Aaa Moody's log yield spread was close to its historical average over the period 1969.Q4 to 2010.Q4.[5] On the other hand, equity valuations were high, with the S&P 500 index dividend-price ratio a full standard deviation below its sample average. Based on our estimates, 34 bps of the 104 bps U.S. Baa-Aaa log yield spread in December 2010 were due to above average inflation pro-cyclicality.

We develop a model with stochastic productivity and optimal but infrequent capital structure choice. This model provides new, testable, and quantitative predictions. Regressions of model credit spreads onto inflation volatility and the inflation-stock correlation predict that the impact of inflation volatility and the inflation-stock correlation on credit spreads should be substantial, while controlling for equity volatility, the dividend yield, inflation surprises, and equity returns. Simulated credit spreads increase by 27 bps if the annualized standard deviation of inflation shocks increases by 1 percentage point and by 20 bps if the inflation-stock correlation increases by 100 percentage points.

Three key features in our model generate large, dynamic responses of credit spreads to inflation risk. First, we model both the size of inflation shocks and their correlation with real outcomes as varying over time independently of real activity.

Second, we assume that firms issue nominal long-term bonds and that expected inflation is persistent, consistent with U.S. and international evidence (Ball and Cecchetti (1990), Stock and Watson (2007)). The assumption that debt is nominal is plausible for developed countries, where bonds are denoted in nominal terms by historical convention, and where inflation-indexed corporate debt plausibly carries a substantial liquidity premium. In our calibrated model, a liquidity premium comparable to that documented for U.S. inflation-indexed government bonds during their first few years of issuance (D'Amico, Kim, and Wei (2009), Pflueger and Viceira (2011)) deters firms from switching to inflation-indexed bonds.

The combination of long-term nominal bonds and persistent inflation implies that small permanent shocks to inflation can have large effects on real liabilities. For instance, a permanent decrease in log inflation from three to one percent per annum increases the expected real principal repayment on a ten-year nominal bond by 22%. Surprise inflation matters for credit spreads above and beyond shocks to the real economy. In contrast, a decrease in the real interest rate also affects credit risk, but it does so because it reflects expected real growth and real risk premia.

Third, firms in our model choose leverage optimally but infrequently, according to a textbook tradeoff theory (Modigliani and Miller (1958), Modigliani and Miller (1963), Kraus and Litzenberger (1973)). Tax and other debt benefits create an incentive for taking on debt, while bankruptcy costs discourage taking on debt. When the ex-ante risk-adjusted cost of bankruptcy increases due to inflation risk, young firms in our overlapping generations model respond by reducing leverage. However, old firms' inability to respond magnifies the increase in credit spreads. The empirically well-founded assumption of infrequent capital structure adjustment helps generate a realistic level of credit spreads.

We provide new empirical evidence that corporate bond investors price the risk of debt deflation in a panel of corporate bond spread indexes from Australia, Canada, Germany, Japan, the United Kingdom, and the United States over four decades. Following authors such as Chen, Collin-Dufresne, and Goldstein (2009), we compute U.S. corporate bond spreads in excess of the Moody's Aaa log yield. Due to their worldwide benchmark status, U.S. Treasuries may enjoy extreme liquidity and therefore the Moody's Aaa yield may provide a better proxy of the long-term default-free bond yield.[6] We calculate spreads in excess of duration-matched government bond log yields for all non-U.S. countries.

In a pooled regression, one standard deviation increases in inflation volatility or the inflation-stock correlation are associated with spread increases of 14 bps. Our proxies for inflation risk explain as much variation in credit spreads as do equity volatility and the dividend-price ratio, our proxies for real uncertainty and risk aversion. Consistent with model predictions, the empirical impact of inflation risk is especially large when real stock returns are low or when inflation shocks are low.

Our empirical evidence from corporate bond spreads is both consistent with predicted model magnitudes and with ex-post realized corporate bond credit losses and risk premia. We test whether inflation risk raises physical expected credit losses, default risk premia, or both, using U.S. data on Baa-rated corporate defaults, loss given default, and long-term corporate log returns in excess of government log returns. We find that a one standard deviation move in U.S. inflation volatility (58 bps) predicts a 10 bps increase in the annual credit loss rate over the next five years, while controlling for the equity volatility, the dividend-price ratio, and business cycle controls. A one standard deviation move in the U.S. inflation-stock correlation (34 percentage points) predicts a 6 bps increase in the annual credit loss rate over the next five years. We find that the inflation-stock correlation, but not the inflation volatility, forecasts excess log returns on long-term corporate bonds over long-term government bonds.

Our results suggest that the inflation-stock correlation raises both expected physical loss rates and default risk premia, and that both channels are quantitatively important. On the other hand, inflation volatility appears to raise expected physical credit loss rates, but not default risk premia. These findings are consistent with our proposed mechanism, where an increase in the inflation-stock correlation should make corporate defaults more likely to occur in the worst economic states when marginal utility is high.

Evidence from the Israeli inflation-indexed corporate bond market provides additional direct evidence that the nominal nature of U.S. and international corporate bonds generates time-varying risk of debt deflation. In contrast to the other financial markets in our sample, Israeli government and corporate bonds have been conventionally inflation-indexed since the 1950s (Koninsky (1997)). Consistent with our proposed theory, we find no evidence that Israeli inflation-indexed corporate bond spreads are driven by time-varying risk of debt deflation. On the contrary, investment grade Israeli inflation-indexed corporate bond spreads increased from 54 bps in 2000.Q1 to 146 bps in 2010.Q4 while inflation volatility decreased from 283 bps to 155 bps.

The findings in this paper have broad implications not only for asset pricing, but also for policy, macroeconomic research, and corporate finance. For instance, firms might optimally want to decrease their share of long-term nominal debt when inflation risk is high.

The remainder of the paper is organized as follows. After a brief literature review, Section I introduces the model. Section II argues that inflation risk should be quantitatively important for credit spreads in a calibrated version of the model. Section III tests the model predictions in an international panel of credit spread indexes, and Section IV concludes.

A. Literature Review

Time variation in inflation volatility was first modeled by Engle (1982). There is also substantial bond market evidence of time-varying inflation cyclicality (Li (2002), Baele, Bekaert, and Inghelbrecht (2010), David and Veronesi (2013), Viceira (2012), Wright (2011), Campbell, Sunderam, and Viceira (2013)).

We add to previous structural models of credit risk such as Merton (1974), and Longstaff and Schwartz (1995) by allowing the risk of inflation to vary over time. We also contribute to the literature on asset pricing models with optimal leverage and default by arguing that firms should adjust their capital structure in response to time-varying inflation risk (Leland and Toft (1996), Goldstein, Ju, and Leland (2001), Hackbarth, Miao, and Morellec (2006), Chen, Collin-Dufresne, and Goldstein (2009), Bhamra, Kuehn, and Strebulaev (2010a), Bhamra, Kuehn, and Strebulaev (2010b), Gomes and Schmid (2010), Gourio (2013)). Our model of optimal firm capital structure has analogies to optimal household mortgage choice under inflation risk (Campbell and Cocco (2003), Koijen, van Hemert, and van Nieuwerburgh (2009)), but it differs in that all assets are priced by the same representative investor.

This paper is closely related to recent models of monetary policy when firms' liabilities are nominal (Bhamra, Fisher, and Kuehn (2011), De Fiore and Tristani (2011)). Our model highlights inflation volatility and inflation cyclicality as driving credit risk, and has directly testable predictions. Transition dynamics in our model increase the quantitative impact of inflation risk on credit spreads.

Ferson and Harvey (1991) estimate the risk premium for exposure to inflation surprises using government bond, corporate bond, and stock portfolio returns for the period 1964 to 1986. We add to their analysis by arguing that the time-varying second moments of inflation surprises are priced into corporate bonds.

I. A Dynamic Model of Inflation Risk in Corporate Bonds

We model production and the optimal choice of capital structure in a standard manner, similarly to Gourio (2013). We depart from standard practice by assuming that corporate debt is nominal and long-term, and by assuming that the second moments of inflation are time-varying. We model overlapping generations of firms to tractably capture infrequent debt refinancing.

A. Intuition: Contingent Claim Payoff Profiles

We illustrate the main model intuition using contingent claim payoff profiles. Black and Scholes (1973) and Merton (1974) model a corporate bond as a default-free bond minus a put option on the underlying firm's assets. In such a framework, credit spreads decrease in the underlying firm's asset value and increase in the volatility of the firm's assets. In our proposed mechanism, an unexpected drop in inflation increases the default probability. Inflation volatility and inflation cyclicality should therefore increase the corporate bond spread. This effect is similar to but separate from the effect of real asset volatility on the credit spread.[7]

[FIGURE 2 ABOUT HERE]

Figure 2 shows conditional expected real payoffs on nominal corporate and default-free bonds for different inflation risk scenarios. In Figure 2B, inflation is uncertain and uncorrelated with real asset values. The default probability is nonzero for any underlying real asset value, and the payoff gap increases relative to Figure 2A.

Comparing Figures 2C and 2D shows that when inflation is pro-cyclical, credit spreads should be higher. In Figure 2C, firms get hit twice during recessions because they experience low real asset values and high real liabilities at the same time. The gap between default-free and corporate bonds is especially large when real asset values are low and risk-averse investors' marginal utility is likely to be high, so credit spreads should increase further to include a larger default risk premium.

B. Timing of Cohort t

[FIGURE 3 ABOUT HERE]

Figure 3 illustrates the timing for a firm that enters at the end of period t and produces for two periods. At the end of period t, the firm chooses its face value of nominal two-period debt $B_t^{\$}$ and purchases capital K_{t+1}^{y}, which will be available for production at time $t+1$. The firm's newly issued corporate bonds have two periods remaining to maturity.

In period $t+1$, aggregate productivity and inflation shocks are realized. The firm experiences an idiosyncratic shock to its capital stock and produces. The firm cannot modify its capital structure, so leverage is sticky. The firm's seasoned corporate bonds have one period remaining to maturity.

In period $t+2$, the firm again receives shocks and produces. At the end of period $t+2$, equity holders decide whether to default. Equity and debt holders then receive payments.

C. Production

Firms have a standard Cobb-Douglas production function with capital and labor inputs. At time t, firm i with capital K_t^i and labor N_t^i produces output Y_t^i:

$$Y_t^i = \left(z_t N_t^i\right)^{1-\alpha} \left(K_t^i\right)^{\alpha}. \tag{1}$$

Total factor productivity (TFP) z_t is independently and identically distributed with a trend:

$$z_{t+1} \quad = \quad \exp(\mu t) \exp\left(\varepsilon_{t+1}^{TFP} - \frac{1}{2}\sigma^2\right) \text{ with } \varepsilon_{t+1}^{TFP} \overset{iid}{\sim} N\left(0, \sigma^2\right). \tag{2}$$

We calibrate one time period to equal five years, which is close to business cycle frequency, so independent TFP shocks are a reasonable approximation. TFP trend μ is also the equilibrium trend growth rate for output and consumption in the economy.

Firm i chooses labor optimally to maximize single period operating revenue, while taking the aggregate wage as given. We assume that the aggregate supply of labor is fixed at 1, abstracting from unemployment. The equilibrium wage adjusts to clear the labor market.

We define aggregate output, capital, and investment at time t by integrating over all firms:

$$Y_t = \int_i Y_t^i di,\ K_t = \int_i K_t^i di,\ N_t = \int_i N_t^i di,\ I_t = \int_i I_t^i di. \tag{3}$$

Capital depreciates at a constant rate δ and we impose the resource constraint that total output equals aggregate consumption plus investment:

$$K_{t+1} = I_t + (1-\delta) K_t, \tag{4}$$

$$Y_t = C_t + I_t. \tag{5}$$

Solving for the equilibrium hiring policy, total output at time t is given by $Y_t = z_t^{1-\alpha} K_t^{\alpha}$. Young and old firms are heterogeneous in their capital stock, but constant returns to scale imply that for any firm the return on capital from time t to time $t+1$ equals:

$$R_{t+1}^K = \left[\alpha \left(\frac{z_{t+1}}{K_{t+1}}\right)^{1-\alpha} + (1-\delta)\right]. \tag{6}$$

From (6) the expected level and the volatility of real returns on capital are endogenously higher when the capital stock K_{t+1} is low relative to trend.

D. Inflation

Let P_t denote the price level at time t and π_t log inflation from time $t-1$ to time t:

$$\pi_t = \log\left(P_t / P_{t-1}\right). \tag{7}$$

Consistent with U.S. and international empirical evidence (e.g., Stock and Watson (2007), Ball and Cecchetti (1990)), we model expected log inflation as following a random walk. The dynamics of expected inflation resemble a backward-looking Phillips curve, consistent with empirical evidence (Fuhrer (1997)). Inflation persistence implies that uncertainty about the price level increases with the time horizon, so inflation risk should be larger for longer maturity bonds:[8]

$$\pi_{t+1} = \pi_t + \varepsilon^{\pi}_{t+1}, \tag{8}$$

$$\varepsilon^{\pi}_{t+1} \big| \sigma^{\pi}_{t+1} \sim N\left(0, \left(\sigma^{\pi}_{t+1}\right)^2\right), \tag{9}$$

$$Corr\left(\varepsilon^{\pi}_{t+1}, \varepsilon^{TFP}_{t+1} \big| \rho^{\pi}_{t+1}\right) = \rho^{\pi}_{t+1}. \tag{10}$$

Higher σ^{π}_t implies more uncertainty about the price level. When ρ^{π}_t is positive, the relation between inflation and real activity slopes upward, similarly to an upward-sloping Phillips curve. When ρ^{π}_t is negative, the Phillips curve is unstable—potentially due to supply shocks or to shifting inflation expectations.

The magnitude of inflation surprises and their relation with productivity shocks can vary over time. We model time variation in σ^{π}_t and ρ^{π}_t in the simplest possible manner by assuming that they follow two-state Markov switching processes, independent of each other and of all other shocks in the economy. Inflation uncertainty σ^{π}_t and inflation cyclicality ρ^{π}_t each take a low or a high value:

$$\sigma^{\pi}_t \in \left\{\sigma^{\pi,L}, \sigma^{\pi,H}\right\}, \ \rho^{\pi}_t \in \left\{\rho^{\pi,L}, \rho^{\pi,H}\right\}. \tag{11}$$

The probabilities of going from state $\sigma^{\pi,X}$ to $\sigma^{\pi,Y}$ and of going from state $\rho^{\pi,X}$ to $\rho^{\pi,Y}$ are:

$$p\left(\sigma^{\pi,X} \rightarrow \sigma^{\pi,Y}\right), \ p\left(\rho^{\pi,X} \rightarrow \rho^{\pi,Y}\right). \tag{12}$$

E. Default Decision

A firm's default decision depends on the initial level of debt, aggregate real shocks, aggregate nominal shocks, and idiosyncratic real shocks.

Corporate debt promises a fixed nominal payment after two periods, when the firm pays a liquidating dividend. We denote logs by small letters throughout. All firms in cohort t are identical ex-ante. Denote the initial log nominal face value of debt by $b_t^{\$}$ and initial log leverage adjusted for expected inflation by l_t. Then firms choose:

$$l_t = b_t^{\$} - 2\pi_t - k_{t+1}^y. \tag{13}$$

Inflation persistence implies that the inflation shock in period $t+1$ enters twice into the log real liabilities of an old firm:

$$b_{t+2}^{real,old} = l_t + k_{t+1}^y - 2\varepsilon_{t+1}^{\pi} - \varepsilon_{t+2}^{\pi}. \tag{14}$$

Firm i in cohort t experiences identical and independent idiosyncratic shocks to log capital at times $t+1$ and $t+2$, $a_{t+1}^{i,1}$ and $a_{t+2}^{i,2}$. We assume:

$$a_{t+2}^{i,id} = a_{t+1}^{i,1} + a_{t+2}^{i,2}, \tag{15}$$

$$a_{t+1}^{i,1}, a_{t+2}^{i,2} \overset{ind}{\sim} N\left(-\frac{1}{4}\left(\sigma^{id}\right)^2, \frac{1}{2}\left(\sigma^{id}\right)^2\right). \tag{16}$$

Using (6) the log real value of an old firm at the end of period $t+2$ equals:

$$v_{t+2}^{i,old} = k_{t+1}^y + r_{t+1}^K + r_{t+2}^K + a_{t+2}^{i,id}. \tag{17}$$

Equity holders have the option to default on debt payments and to receive a zero liquidating dividend. They optimally decide to default if and only if the real value of the firm (17) is less than its real liabilities (14).[9] Conditional on aggregate shocks, firms with the most adverse idiosyncratic shocks default:

$$a^{i,id}_{t+2} < \underbrace{l_t - 2\varepsilon^{\pi}_{t+1} - \varepsilon^{\pi}_{t+2} - r^K_{t+1} - r^K_{t+2}}_{\text{Survival Threshold } a^*_{t+2}}. \tag{18}$$

Equation (18) formalizes the intuition that low inflation shocks ε^{π}_{t+1} and ε^{π}_{t+2} increase the survival threshold a^*_{t+2} and defaults. Low productivity shocks at times $t+1$ and $t+2$ lower real returns on capital and also increase defaults. The real interest rate does not enter into the default threshold directly. However, a drop in real interest rates either reflects a fall in expected real growth rates or a change in real risk premia, which can affect default risk.

F. Stochastic Discount Factor

We model a representative consumer with expected power utility over consumption, risk aversion γ, and discount rate β:

$$U_t = \mathbb{E}_t \sum_{s=t}^{\infty} \exp\left(-\beta\left(s-t\right)\right) \frac{C_s^{1-\gamma}}{1-\gamma}. \tag{19}$$

The two-period stochastic discount factors for pricing two-period real and nominal payoffs are:

$$M_{t,t+2} = \exp\left(-2\beta\right)\left(C_{t+2}/C_t\right)^{-\gamma}, \tag{20}$$

$$M^{\$}_{t,t+2} = M_{t,t+2}/\exp\left(2\pi_t + 2\varepsilon^{\pi}_{t+1} + \varepsilon^{\pi}_{t+2}\right). \tag{21}$$

G. Corporate Bond Prices

Let the functions $H(a^*_{t+2})$, $\Omega(a^*_{t+2})$ denote the time $t+2$ default probability and average defaulted firm value conditional on the survival threshold a^*_{t+2}. Let $G(a^*_{t+1}, a_t^{i,1})$ and $W(a^*_{t+1}, a_t^{i,1})$ denote the time $t+1$ default probability and average defaulted firm value of a cohort $t-1$ firm conditional on the survival threshold a^*_{t+1} and on the firm's first-period idiosyncratic shock $a_t^{i,1}$:

$$
\begin{aligned}
H\left(a^*_{t+2}\right) &= \mathbb{P}\left(a^{i,id}_{t+2} < a^*_{t+2}\right), & (22)\\
\Omega\left(a^*_{t+2}\right) &= \mathbb{E}\left(\exp\left(a^{i,id}_{t+2}\right)\mathbb{I}\left(a^{i,id}_{t+2} < a^*_{t+2}\right)\right), & (23)\\
G\left(a^*_{t+1}, a_t^{i,1}\right) &= \mathbb{P}\left(a^{i,id}_{t+1} < a^*_{t+1} \,\middle|\, a_t^{i,1}\right), & (24)\\
W\left(a^*_{t+1}, a_t^{i,1}\right) &= \mathbb{E}\left(\exp\left(a^{i,id}_{t+1}\right)\mathbb{I}\left(a^{i,id}_{t+1} < a^*_{t+1}\right) \,\middle|\, a_t^{i,1}\right). & (25)
\end{aligned}
$$

Here, $\mathbb{I}$ denotes the indicator function. The prices of a new corporate bond at time t and a duration-matched two-period government bond then equal:

$$
\begin{aligned}
q_t^{corp,new} &= \mathbb{E}_t\left[M^{\$}_{t,t+2}\left(1 - \underbrace{H\left(a^*_{t+2}\right)}_{\text{Default Rate}} + \theta\underbrace{\frac{\Omega\left(a^*_{t+2}\right)}{\exp\left(a^*_{t+2}\right)}}_{\text{Recovery Rate}}\right)\right], & (26)\\
q_t^{gov,2} &= \mathbb{E}_t\left[M^{\$}_{t,t+2}\right]. & (27)
\end{aligned}
$$

Similarly, firm i's seasoned corporate bond and a duration-matched one-period government bond are then priced according to:

$$q_t^{i,seas} = \mathbb{E}_t\left[M^{\$}_{t,t+1}\left(1-\underbrace{G(a^*_{t+1},a_t^{i,1})}_{\text{Cond. Def. Rate}}+\theta\underbrace{\frac{W(a^*_{t+1},a_t^{i,1})}{\exp\left(a^*_{t+1}\right)}}_{\text{Cond. Recovery}}\right)\right], \tag{28}$$

$$q_t^{gov,1} = \mathbb{E}_t\left[M^{\$}_{t,t+1}\right]. \tag{29}$$

Let $\overline{\log q_t^{i,seas}}$ denote the log seasoned corporate bond price averaged across firms. We define credit spreads as the average log yield spread:

$$spread_t^{new} = -\frac{1}{2}\log q_t^{corp,new}+\frac{1}{2}\log q_t^{gov,2}, \tag{30}$$

$$spread_t^{seas} = -\overline{\log q_t^{i,seas}}+\log q_t^{gov,1} \tag{31}$$

Note that these measures are not mechanically linked to the level of inflation expectations in the nominal stochastic discount factor.

H. Capital Structure Choice

Firms choose leverage according to a standard tradeoff view of capital structure. We follow Gourio (2013) in assuming that firms receive benefits $\chi > 1$ for each dollar of debt issued. Equity holders of cohort t firms choose capital K^y_{t+1} and nominal liabilities $B^{\$}_t$ subject to the budget constraint:

$$K^y_{t+1} = \underbrace{S_t}_{\text{Value of New Equity}} + \chi \times \underbrace{q_t^{corp,new}}_{\text{New Nominal Bond Price}} \times B^{\$}_t. \tag{32}$$

Higher χ increases the incentive to raise leverage. There is a debate whether tax benefits are sufficiently large to explain observed leverage ratios (Graham (2000), Almeida and Philippon (2007)).

We interpret χ broadly to include more general benefits and costs of debt, such as constraining managers from empire-building and reducing informational asymmetries (Jensen and Meckling (1976), Myers (1977), Myers and Majluf (1984), Jensen (1986)).

Equity holders trade off the benefits of debt with expected bankruptcy costs. We assume that debt investors only recover a constant fraction $\theta < 1$ of firm value in bankruptcy, see also Leland (1994). A lower recovery rate θ reduces the incentive to lever up. There exists an interior optimal leverage ratio if bankruptcy costs are sufficiently large relative to debt benefits. We formally assume that $\theta\chi < 1$ (Gourio (2013)).

By imposing the resource constraint (5), we follow Gourio (2013) in assuming that bankruptcy costs and debt benefits are redistributive and do not have a direct effect on output. This simplifying assumption should not substantially affect the model results, as long as time variation in default rates is small relative to aggregate output fluctuations.

We define the marginal default probability:

$$h\left(a_{t+2}^*\right) = H'\left(a_{t+2}^*\right). \tag{33}$$

Equity holders equate the marginal benefit of raising another dollar of debt with the increase in bankruptcy costs according to the first-order condition:

$$0 = \underbrace{-\chi(1-\theta)\,\mathbb{E}_t\left(M_{t,t+2}^{\$} h\left(a_{t+2}^*\right)\right)}_{\text{Marginal Bankruptcy Cost}} + \underbrace{(\chi-1)\,\mathbb{E}_t\left(M_{t,t+2}^{\$}\left(1-H\left(a_{t+2}^*\right)\right)\right)}_{\text{Marginal Benefit of Debt}}. \tag{34}$$

Firms choose the optimal level of capital, yielding the first-order condition:

$$1 = \mathbb{E}_t \left[M_{t,t+2} R^K_{t+1} R^K_{t+2} F_{t+2} \right], \quad (35)$$

$$F_{t+2} = 1 - \underbrace{(1-\theta\chi)\,\Omega\left(a^*_{t+2}\right)}_{\text{Bankruptcy Cost}} + \underbrace{(\chi-1)\exp\left(a^*_{t+2}\right)\left(1 - H\left(a^*_{t+2}\right)\right)}_{\text{Benefit of Debt}}. \quad (36)$$

The Euler equation (35) says that the expected discounted return on capital, adjusted for bankruptcy costs and benefits of debt by the factor F_{t+2}, equals 1. Inflation affects the first-order conditions (34) and (35) through the survival threshold a^*_{t+2}. When inflation is more volatile or more pro-cyclical, the default threshold becomes more volatile and marginal bankruptcy costs increase. While equity holders do not incur any bankruptcy costs upon default, debt investors require compensation for bankruptcy costs ex-ante, incentivizing firms to reduce leverage ratios.

II. Calibrated Model

A. Parameter Values and Model Moments

We show two model calibrations, which separately capture time-varying inflation volatility and time-varying inflation cyclicality. Model 1 focuses on stochastic inflation volatility and holds the correlation between inflation shocks and TFP shocks constant at 0. Model 2 holds inflation volatility constant, but allows the inflation-TFP correlation to vary.

We focus on moderate inflation volatility to highlight the relevance of inflation risk for credit spreads even in a stable inflation environment. In Model 1, the standard deviation of annual inflation expectation shocks switches between 0% and 2%. The higher volatility of 2% corresponds approximately to the U.S. experience in the early 1980s, and is half as large as our estimate of U.K. inflation volatility during the late 1970s. To focus on the impact of inflation volatility, we set the inflation-TFP correlation to zero. Volatility states are persistent, consistent with a five-year autoregressive coefficient for U.S. inflation volatility of 0.5. The volatility process spends about two-thirds of its time in the low state.

In Model 2, we assume that the inflation-TFP correlation follows a symmetric process, switching between -0.6 and 0.6, within the range of our empirical estimates for the inflation-stock return correlation in developed countries.[10] We study the impact of inflation cyclicality with moderate inflation uncertainty of 1% per annum (p.a). The average duration for each state is 15 years, consistent with three different regimes over a forty-year period.

[TABLE I ABOUT HERE]

Parameter values are summarized in Table I. We face a tradeoff in choosing the length of the time period. Five-year time periods imply that seasoned corporate bond durations are slightly shorter than their empirical counterparts, and that firm leverage and investment are constant for ten-year periods.[11] We choose standard values for the capital share, depreciation, and the discount rate (Cooley and Prescott (1995)). We choose a risk aversion of 10, the upper bound of plausible coefficients of risk aversion considered by Mehra and Prescott (1985). We constrain trend growth to be equal to average U.S. real GDP growth between 1970 and 2009. The recovery rate in bankruptcy equals 40%, consistent with the empirical evidence in Altman (2006).[12] The debt benefit parameter is a free parameter, and we choose $\chi = 1.4$ to generate empirically plausible default rates. Almeida and Philippon (2007) calculate that tax benefits account for approximately 16% of the debt value, so our high benefits incorporate significant agency benefits of debt.

[TABLE II ABOUT HERE]

Table II reports calibrated asset price moments together with empirical U.S. moments from 1970 to 2009.[13] The high volatility of TFP shocks and idiosyncratic shocks generate plausible levels of aggregate and idiosyncratic equity market volatility. We do not attempt to explain the equity volatility puzzle (Shiller (1981), LeRoy and Porter (1981)), which can be resolved if consumption and dividend growth contain a time-varying long-run component (e.g., Bansal and Yaron (2004)), or if preferences induce persistent fluctuations in risk premia (e.g., Campbell and Cochrane (1999)).

Unexpectedly low inflation also increases real off-balance sheet liabilities, such as defined benefit pension plans, health care obligations, and operating leverage. Pension obligations were especially salient during the United Airlines bankruptcy negotiations in the 2000s (Maynard (2005)). Jin, Merton, and Bodie (2006) argue that a firm's equity risk reflects the risk of its pension plan. Shivdasani and Stefanescu (2010) and Bartram (2012) calculate that consolidating post-retirement benefits can increase leverage by about a third. We interpret model leverage of 41% broadly to include off-balance sheet liabilities.

We compare the seasoned model credit spread to the average Moody's Baa over Aaa log yield, which is based on secondary market prices rather than prices at issuance. Recent papers have argued that structural models of credit risk can only explain a small portion of empirical credit spreads while matching historically low default rates (Huang and Huang (2012)). We obtain high credit spreads with plausible default rates due to volatile TFP shocks and to high risk aversion. Leverage ratios of model seasoned firms are heterogeneous across firms, and credit spreads are convex in leverage ratios, so the cross-section of firms further raises average credit spreads (Bhamra, Kuehn, and Strebulaev (2010a), Bhamra, Kuehn, and Strebulaev (2010b)).

Our model raises the question of why firms do not issue inflation-indexed debt. If bond issuance in our sample countries is nominal by historical convention, it is plausible that inflation-indexed corporate bond yields would contain a liquidity premium. Such a liquidity premium could capture investors' and issuers' increased accounting and training expenses from holding both nominal and indexed bonds at the same time. U.S. government inflation-indexed bond yields, first issued in 1997, initially contained a substantial liquidity premium of over 50-100 bps (Pflueger and Viceira (2011)).

Our model is consistent with a nominal-only corporate bond market for plausible liquidity premia. Consider the problem of an infinitely small firm, which can deviate from the nominal-only equilibrium by issuing inflation-indexed bonds. In our calibrated model, such a firm finds it optimal to continue issuing nominal debt as long as the liquidity premium in corporate inflation-indexed bond yields is at least 29 bps. For the derivation of the optimality condition, see Supplementary Appendix C.

B. Model Implications for Credit Spreads

[TABLE III ABOUT HERE]

Table III shows that calibrated credit spreads are highly sensitive to both inflation volatility and the inflation-stock correlation, even for moderate levels of inflation volatility. We focus on seasoned credit spreads, which take into account non-optimal and heterogeneous firm leverage ratios and correspond most closely to empirical secondary market prices of corporate debt. We estimate the following model regressions:

$$\begin{aligned} &\text{Model 1:} \quad spread_t^{seas} = \lambda_1^0 + \lambda_1^{\sigma^\pi}\sigma_t^\pi + \lambda_1^{\sigma^{eq}}\sigma_t^{eq} + \lambda_1^{DP} DP_t^{seas} + \lambda_1^{eq} r_t^{eq} + \lambda_1^\pi \varepsilon_t^\pi + \eta_{1,t}, \\ &\text{Model 2:} \quad spread_t^{seas} = \lambda_2^0 + \lambda_2^{\rho^\pi}\rho_t^\pi + \lambda_2^{\sigma^{eq}}\sigma_t^{eq} + \lambda_2^{DP} DP_t^{seas} + \lambda_2^{eq} r_t^{eq} + \lambda_2^\pi \varepsilon_t^\pi + \eta_{2,t}. \end{aligned} \tag{37}$$

We report means and standard deviations of regression coefficients from 500 simulated time series of length 100. The simulation length corresponds to approximately forty years of independent bi-annual data from five countries. Since our empirical quarterly observations are likely correlated over time and across countries, we have to exercise caution in relating the model standard errors to empirical standard errors.[14]

A one percentage point increase in the standard deviation of annual inflation shocks leads to an economically significant increase in credit spreads of 27 bps (Panel A). Credit spreads increase by 20 to 27 bps as the inflation-stock return correlation increases by 100 percentage points. As we go from column (1) to column (2) in Panel A, we add inflation volatility as an explanatory variable, and the regression R^2 increases by four percentage points. Adding the inflation-stock correlation in Panel B similarly increases the regression R^2 by two percentage points.

Equity returns, inflation shocks, equity volatility, and the dividend-price ratio enter with the expected signs in Table III. Capital structure adjustments are slow and therefore high equity returns and high inflation shocks decrease seasoned firms' leverage and credit risk. Model real interest rates reflect time-varying expected consumption growth and time-varying precautionary savings, and are highly correlated with the dividend-price ratio and equity volatility, so controlling for real interest rates would not explain any additional variation in model credit spreads.

Our right-hand side variables can jointly account for over 80% of the variation in credit spreads, which is unsurprising because the simulated model credit spreads are a function of real shocks, nominal shocks, and the inflation risk regime. We would not expect an equally high R^2 in our empirical results, especially if empirical nominal and real shocks were imperfectly measured.

[FIGURE 4 ABOUT HERE]

Intuitively, inflation risk matters most when stock returns are low or when inflation is unexpectedly low. Figure 4 shows that inflation volatility and the inflation-TFP correlation increase credit spreads especially strongly when stock returns and inflation surprises are low.[15] The asymmetry in Figure 4 is large relative to the average effect of inflation risk on credit spreads. For instance, the difference between high inflation volatility credit spreads and low inflation volatility credit spreads is 133 bps larger in the lowest stock return quintile than in the middle stock return quintile.

III. Empirical Inflation Risk and Corporate Bonds

A. Data Description

We compute credit spreads as the continuously compounded (or log) corporate bond index yield over the log default-free yield, analogously to model corporate bond spreads. This credit spread also equals the log of (one plus) the proportional credit spread, and is therefore not mechanically linked to inflation expectations.

U.S. Treasury yields may not equal the risk-free rate due to their benchmark status in worldwide financial markets. Following authors such as Chen, Collin-Dufresne, and Goldstein (2009), we use the Moody's Baa over Aaa log yield spread as a measure of credit risk in long-term U.S corporate bonds. Subtracting the Aaa log yield should also help adjust for tax and callability effects on corporate bond yields, if those are similar for corporate bonds with different ratings. Historical defaults of Aaa rated bonds have been extremely rare, but any default component in Aaa bond yields should bias us against finding an empirical result. Our results become even stronger using the Baa-Treasury spread, as shown in Table B.IV in the Supplementary Appendix. Non-U.S. credit spreads are computed in excess of a duration-matched government bond yield.

We obtain corporate bond yield indexes, government bond yields, GDP growth, stock returns, and CPI inflation from *Global Financial Data* (*GFD*).[16]

We obtain empirical proxies for each country's standard deviation of equity returns, standard deviation of inflation surprises, and inflation-stock correlation from a rolling three-year backward-looking window of quarterly log real stock return surprises and log inflation surprises. Unexpected log inflation is the residual from a regression of quarterly log inflation onto its own four lags, the lagged log T-bill, and seasonal dummies. The quarterly log real stock return shock is the residual from regressing the quarterly log real stock return onto its own first lag. Real GDP growth surprises are estimated analogously to inflation surprises by regressing log real GDP growth onto its own four lags, the lagged log T-bill, and seasonal dummies.

Our baseline inflation forecasting regression follows Campbell, Sunderam, and Viceira (2013) and Campbell and Shiller (1996). A number of different inflation forecasting relations have been proposed in the literature. Atkeson and Ohanian (2001) argue that inflation over the past year outperforms Phillips curve-based inflation forecasts, which also include a measure of real activity, in the U.S. after 1984. We verify in the Supplementary Appendix Table B.V that our empirical results are robust to including lagged log real stock returns and to excluding the nominal T-bill; the results are also robust to rolling forecasts, the Atkeson and Ohanian (2001) model, and a wide range of reasonable inflation forecasting models considered in Stock and Watson (2007). We use consumer prices to measure inflation risk, but our results are robust to using a producer price index.

We control for lagged stock returns, real GDP growth, unemployment, and lagged inflation surprises. We explicitly control for equal-weighted market leverage ratios of non-financial *Compustat* firms over a shorter time period.[17]

We control for the volatility of real quarterly stock returns and the volatility of real quarterly GDP growth. We also control for idiosyncratic stock return volatility, when available. We follow Campbell, Lettau, Malkiel, and Xu (2001) in decomposing individual daily stock returns into a market component, an industry component, and a firm component. Idiosyncratic volatility is calculated as the volatility of the firm component over the past quarter, averaged over all individual stocks.[18]

In our model the dividend-price ratio helps capture the time-varying risk of equity returns, while in a model of time-varying risk aversion, such as in Campbell and Cochrane (1999), it serves as a proxy for aggregate risk aversion. We therefore control for the dividend-price ratio from *Datastream*.[19]

Campbell, Sunderam, and Viceira (2013) have argued that the comovement between nominal government bond returns and stock returns reflects time-varying inflation risk. If nominal long-term bond yields reflect long-term inflation expectations, the correlation between changes in nominal government log yields and log real stock returns should reflect investors' perception of inflation cyclicality. Similarly, the volatility of changes in nominal government log yields should reflect inflation volatility. However, bond volatility and the bond-stock correlation may also reflect real interest rate risk, and it is therefore important to control for them. We construct the bond-stock correlation and bond volatility using daily or weekly government bond and stock returns over the past quarter, using the highest frequency available.[20]

The difference between nominal and inflation-indexed bond yields, or breakeven inflation, is the inflation rate that would equalize ex-post returns on nominal and inflation-indexed bonds. If inflation risk and liquidity components in breakeven change only slowly over time, the correlation between changes in breakeven and stock returns should give a high-frequency, financial markets-based measure of the inflation-stock correlation. Indeed, Figure B.3 in the Supplementary Appendix shows that the nominal bond-stock correlation tracks the breakeven-stock correlation very closely over the available samples 1999 to 2010 in the U.S. and 1985 to 2010 in the U.K, suggesting that much of the time-variation in the nominal bond-stock correlation reflects time-varying inflation risk.

B. Summary Statistics

[TABLE IV ABOUT HERE]

Summary statistics in Table IV reveal that both the volatility and the cyclicality of inflation have varied substantially over time in each country. Average annualized inflation volatility ranges from 101 bps for Germany to 161 bps for the U.K., consistent with the average inflation volatility in our calibrated model. Inflation volatility displays significant time variation within each country with standard deviations around the U.S. value of 58 bps. Inflation volatility in our sample reached a peak of 412 bps in the U.K. during the 1970s, which exceeds the largest inflation volatility in our calibrated model by a factor of two.

The inflation-stock correlation, our measure of the slope of the Phillips curve, is negative or zero on average in every country. Its time variation within each country is substantial, with standard deviations close to the U.S. value of 0.34.

Credit spreads average around 100 bps and have within country standard deviations between 32 bps and 98 bps. Rare negative values are most likely due to measurement error. The correlations of international credit spreads with U.S. credit spreads, shown in Table B.2 in the Supplementary Appendix, range from -0.17 for Japan to 0.71 for Australia, so international credit spreads are not perfectly correlated.

[FIGURE 5 ABOUT HERE]

Figure 5 shows the clear time-series comovement between international credit spreads and inflation volatility in each country. Figure 5 indicates that when a country has higher inflation volatility, it also has higher credit spreads. U.S. inflation volatility and credit spreads were both high in the 1970s and 1980s. Both inflation volatility and credit spreads were even more elevated in the U.K. during the same period.

[FIGURE 6 ABOUT HERE]

Figure 6 visually illustrates the positive relation between international credit spreads and the inflation-stock correlation. The U.S. inflation stock correlation was at an all-time high at the end of 2010, indicating procylical inflation. At the same time, credit spreads peaked during the financial crisis. In contrast, the U.S. inflation-stock return correlation was mostly negative during the 1970s and 1980s, indicating that supply shocks and shifting inflation expectations moved inflation and real outcomes in opposite directions.[21]

C. Benchmark Results

Our main empirical tests in Table V proceed as follows. We first report a pooled regression of credit spreads against business cycle controls.[22] We then add inflation risk proxies, equity volatility, and the dividend-price ratio. Finally, we add time fixed effects and investigate the robustness of our results to additional controls and sub-periods.

We estimate a pooled regression of the country i quarter t credit spread, $spread_{i,t}$, on country fixed effects, λ_i^0, measures of inflation volatility, $\sigma_{i,t}^{\pi}$, the inflation-stock correlation, $\rho_{i,t}^{\pi}$, equity volatility, $\sigma_{i,t}^{eq}$, the dividend yield, $DP_{i,t}$, and a vector of control variables, $X_{i,t}$:

$$spread_{i,t} = \lambda_i^0 + \lambda^{\sigma^{\pi}} \sigma_{i,t}^{\pi} + \lambda^{\rho^{\pi}} \rho_{i,t}^{\pi} + \lambda^{\sigma^{eq}} \sigma_{i,t}^{eq} + \lambda^{DP} DP_{i,t} + \Lambda \times X_{i,t} + \eta_{i,t}. \tag{38}$$

The standard errors take into account potential cross-country correlation, heteroskedasticity, and serial autocorrelation. We use Driscoll and Kraay (1998)'s extension of Newey and West (1987) standard errors with 16 lags, as implemented by Hoechle (2007). Corporate bond markets vary significantly across countries. Our regressions therefore contain country fixed effects.[23]

[TABLE V ABOUT HERE]

Table V shows that inflation volatility and the inflation-stock correlation are important in explaining the time- and cross-country variation in credit spreads. Inflation volatility and the inflation-stock correlation both enter with positive, large, and significant coefficients, which are close to the model coefficients in Table III.

We note the following results in Table V. First, inflation volatility and the inflation-stock correlation jointly increase the residual R^2 by nine percentage points relative to a regression of credit spreads onto business cycle controls. In comparison, equity volatility and the dividend-price ratio raise the residual R^2 only by three percentage points. Including inflation volatility and the inflation-stock correlation in addition to equity volatility and the dividend-price ratio raises the residual R^2 by eight percentage points. Taken together, the regressions in columns (1) through (5) show that inflation risk can explain at least as much variation in credit spreads as equity volatility and the dividend-price ratio.

Second, our benchmark estimation in column (5) shows that a 58 bps move in inflation volatility, or one standard deviation in U.S. inflation volatility, is associated with a 14 bps increase in empirical credit spreads. A one standard deviation move in the inflation-stock correlation (34 percentage points) is associated with a 14 bps increase in credit spreads. The magnitudes are economically meaningful relative to average credit spreads of around 100 bps. The empirical effect of inflation volatility on credit spreads is extremely close to the theoretical magnitude in Table III. The empirical slope coefficient of the inflation-stock correlation is somewhat larger, but within two standard deviations of the theoretical slopes in Table III.

The sensitivities of credit risk with respect to real growth shocks and inflation shocks play crucial roles in our proposed mechanism. We include inflation surprises to disentangle the effect of news about the level of inflation and inflation risk, which is especially important if inflation surprises and the second moments of inflation are correlated. Quarterly and three-year inflation shocks enter negatively, and in some specifications significantly, with magnitudes comparable to model slopes in Table III. Our measures of inflation surprises could plausibly contain larger measurement error than the second moments of inflation if the timing of inflation surprises is imprecisely measured. Quarterly real GDP growth enters with a large and negative coefficient, but the coefficients on real growth variables need to be interpreted with caution because of collinearity between different real activity controls.

The coefficients on inflation volatility and the inflation-stock correlation are remarkably stable across different specifications. Including time fixed effects in column (6) shows that the results are not driven by any global omitted variable, such as global real interest rate risk, global growth risk, or global time-varying liquidity. From our theoretical analysis, we would expect that inflation risk should have especially large effects on credit spreads during crises. Excluding the financial crisis in column (7), we find that the inflation volatility and inflation-stock correlation coefficients decrease by about 35% relative to their full-sample values, but that they remain positive and statistically significant. In column (8) we find that GDP volatility does not enter significantly in addition to our main control for uncertainty about long-term real asset values, equity volatility, and other control variables.

We include the slope of the yield curve and the nominal T-bill in column (8), and find that our benchmark results are unchanged. Empirical credit spread indexes contain both callable and non-callable bonds. Duffee (1998) shows that callability features can substantially affect credit spreads, and that the T-bill and the slope of the nominal yield curve can help capture the value of the call option. To the extent that controlling for the slope of the yield curve and the nominal T-bill captures the value of the corporate bond call features, column (8) indicates that our empirical results are not driven by the value of corporate bond call options.

Nominal government bond yields should reflect inflation expectations, inflation risk premia, and real interest rates. The results in column (8) therefore indicate that corporate bond yields price inflation risk above and beyond the effect of inflation risk on nominal government bond yields. Interestingly, the slope coefficients for the log T-bill and log yield curve slope are within two standard deviations of the theoretical inflation shock coefficient in Table III, which is what we would expect if inflation expectations are an important determinant of long-term nominal government bond yields.

In column (9) we include as additional control variables idiosyncratic equity volatility, market leverage, the nominal government bond volatility, and the bond-stock correlation over a shorter sample period starting in 1989. The bond-stock correlation and the bond volatility enter positively and significantly with large regression coefficients, while inflation volatility and the inflation-stock correlation remain statistically significant. The bond-stock correlation and the bond volatility control for real interest rate risk. However, to the extent that these variables reflect inflation risk, we interpret the results in column (9) as additional evidence that inflation risk is priced into credit spreads.

Having estimated the pooled regression (38) in an international panel of forty years of quarterly data, we now estimate the same relation for the U.S. time series of credit spreads. This time series is likely to be especially familiar to readers, and we can include additional liquidity controls for the U.S. Campbell and Taksler (2003) have argued forcefully that idiosyncratic equity volatility is an important determinant of credit spreads and we control for it in our U.S. time series regressions throughout.

[TABLE VI ABOUT HERE]

Table VI shows that U.S. credit spreads are clearly related to inflation risk, although the smaller sample size reduces the statistical power relative to Table V. Inflation volatility enters with a positive and significant coefficient, which is slightly larger than the comparable coefficient in the pooled international regression. The inflation-stock correlation coefficient is positive, but not significant for the full time series. However, for the pre-crisis sub-sample it is positive and indistinguishable from the model coefficient in Table III. The different result for the full sample could potentially reflect a small number of observations during the financial crisis when measurement error was arguably substantial. Going from column (4) to column (5) shows that inflation risk increases the regression R^2 from 61% to 73%.

Given that our time series includes the financial crisis of 2008 to 2009, it is important to control for time-varying corporate bond liquidity using several liquidity proxies. We follow Gârleanu and Pedersen (2011) by including the three-month Eurodollar over T-bill spread as a liquidity control. Gârleanu and Pedersen (2011) argue that funding constraints and margin requirements can create a price wedge between assets with identical cash flows but different margin requirements. Gârleanu and Pedersen (2011) predict that the Eurodollar over T-bill spread and the price gap between credit default swaps and corporate bonds should be tightly linked and provide empirical evidence in the time series and in the cross-section. Intuitively, larger corporate bond mispricings can persist when hedge funds and other arbitrageurs face tight funding constraints, as proxied by the Eurodollar over T-bill spread. Using the Eurodollar over T-bill spread as a corporate bond liquidity proxy is also consistent with previous work on the determinants of corporate bond spreads (Campbell and Taksler (2003)).[24]

We also include the off-the-run on-the-run U.S. nominal Treasury yield spread, which reflects liquidity in the U.S. Treasury market (Krishnamurthy (2002)). We think of the off-the-run spread as capturing a liquidity component that is common across U.S. Treasury and corporate bond markets, consistent with the evidence in Ericsson and Renault (2006).[25] Both the Eurodollar over T-bill spread and the off-the-run spread enter with positive coefficients, as we would expect, but they leave the inflation volatility coefficient unchanged.

[FIGURE 7 ABOUT HERE]

We next explore the asymmetric model implications: the impact of inflation risk on credit spreads should be especially strong when either real stock returns or inflation surprises are low. Figure 7 shows empirical analogues to the theoretical relations in Figure 4, using a non-parametric approach.

We construct the top left panel in Figure 7 by splitting observations in each country into quintiles of real stock returns and into equal-sized subsamples for high and low inflation volatility. We sort by three-year real stock returns for consistency with the construction of the inflation risk variables. The panel averages credit spreads across all countries within each inflation risk regime and quintile and shows credit spreads relative to the middle quintile credit spread. The other panels are constructed similarly.

The empirical relationships between credit spreads, stock returns, and inflation shocks in Figure 7 bear striking resemblance to the theoretical relationships in Figure 4. The top left panel in Figure 7 shows that the gap between credit spreads in the high and low inflation volatility regimes widens by 30 bps in the lowest stock return quintile, indicating a larger put option in defaultable bonds when inflation uncertainty is greater. This number is smaller, but a substantial fraction of the theoretical analogue in Figure 4 of 133 bps.

The top right panel of Figure 7 similarly suggests that the impact of inflation volatility on credit spreads is larger when inflation is surprisingly low, even if the largest difference in credit spreads obtains in the second-lowest quintile of inflation shocks rather than the lowest.

In our benchmark empirical results, a one standard deviation move in either inflation volatility or the inflation-stock correlation is associated with a credit spread increase of 14 bps. In comparison, the empirical magnitudes in Figure 7 are large. However, the magnitudes in Figure 7 are smaller than the theoretical magnitudes in Figure 4. Besides measurement error, one reason is that in Figure 7 we average the above median and below median inflation risk regimes, while in Figure 4 we compare credit spreads at the largest and the smallest values of inflation risk.

Further robustness checks, including individual country regressions, different inflation indexes, inflation forecasting models, and HP filtered explanatory variables are reported in the Supplementary Appendix. Table B.IV in the Supplementary Appendix in particular shows that our benchmark results in Table V become stronger when we compute the U.S. credit spread with respect to a duration-matched government bond log yield instead of the Moody's long-term Aaa log yield.

D. Expected Credit Losses and Default Risk Premia

The mechanism we propose predicts that both inflation volatility and the inflation-stock correlation raise expected losses from bond defaults. An increase in the inflation-stock correlation also increases the likelihood that credit losses will occur in stock-market downturns, when marginal utility of risk-averse investors is likely to be high. An increase in the inflation-stock correlation should therefore raise the required excess return on corporate bonds over default-free bonds and the default risk premium in corporate bond yields. In contrast, an increase in inflation uncertainty may raise defaults and credit losses in both high and low marginal utility states, such as in the contingent claim payoff profile depicted in Figure 2B. Therefore, an increase in inflation volatility does not need to give rise to a default risk premium.

We estimate the effect of inflation volatility and the inflation-stock correlation on the n-year credit loss rate $loss_{US,t\rightarrow t+n}$, defined as the product of default rates and loss given default.[26] Table VII regresses annual credit loss rates on inflation volatility, the inflation-stock correlation, and control variables:

$$\underbrace{loss_{US,t\rightarrow t+n}}_{\text{Loss rate}} = \lambda_{US}^{0} + \lambda^{\sigma^{\pi}} \sigma_{US,t}^{\pi} + \lambda^{\rho^{\pi}} \rho_{US,t}^{\pi} + \lambda^{\sigma^{eq}} \sigma_{US,t}^{eq} + \lambda^{DP} DP_{US,t} + \Lambda X_{US,t} + \eta_{US,t}. \quad (39)$$

[TABLE VII ABOUT HERE]

Columns (1) through (5) of Table VII show that both inflation volatility and the inflation-stock correlation predict credit losses positively and significantly over the next two through five years while controlling for idiosyncratic equity volatility, the dividend-price ratio, inflation surprises, stock return surprises, GDP growth, and unemployment. The inflation volatility and inflation-stock correlation coefficients are positive at all horizons and largest at the three-year forecasting horizon. A one standard deviation move in U.S. inflation volatility (58 bps) predicts a 10 bps increase in the annual credit loss rate over the next five years. This magnitude is statistically indistinguishable from our baseline results on credit spreads, indicating that investors accurately price expected credit losses due to increased inflation uncertainty. A one standard deviation move in the U.S. inflation-stock correlation (34 percentage points) predicts a 6 bps increase in the annual credit loss rate over the next five years. This magnitude is about half the empirical effect of the inflation-stock correlation on credit spreads documented in Table V.

Columns (6) through (10) show that including a comprehensive set of control variables leaves the inflation volatility and inflation-stock correlation coefficients unaffected. Inflation volatility remains a strongly significant forecaster of credit losses at the three- and four-year horizons, while the inflation-stock correlation remains significant at the three-year forecasting horizon. Column (10) shows that at the five-year forecasting horizon, inflation volatility and the inflation-stock correlation remain marginally significant while none of the additional control variables enters significantly. Supplementary Appendix Table B.VIII shows that the results are robust to using default rates.

[TABLE VIII ABOUT HERE]

Table VIII predicts U.S. long-term corporate bond log returns in excess of long-term government bond log returns using lagged inflation volatility, the lagged inflation-stock correlation, and control variables.[27] We estimate the regression:

$$\begin{aligned} ret^{corp}_{US,t\to t+n} - ret^{gov}_{US,t\to t+n} &= \lambda^{0}_{US} + \lambda^{\sigma^{\pi}}\sigma^{\pi}_{US,t} + \lambda^{\rho^{\pi}}\rho^{\pi}_{US,t} \\ &\quad + \lambda^{\sigma^{eq}}\sigma^{eq}_{US,t} + \lambda^{DP}DP_{US,t} + \Lambda \times X_{US,t} + \eta_{US,t}. \end{aligned} \tag{40}$$

Table VIII shows that a one standard deviation move in the inflation-stock correlation (34 percentage points) predicts an increase in corporate bond excess returns of 51 bps over the next quarter and of 126 bps over the next five years. On the other hand, Table VIII provides no evidence that inflation volatility predicts corporate bond excess returns.

A rough calculation allows us to compare the magnitudes in Table VIII to those in Table V. If the duration of the Ibbotson long-term corporate bond index is comparable to that of the Moody's long-term corporate bond index (10.7 years), then a one standard deviation move in the U.S. inflation-stock correlation (34 percentage points) corresponds to an increase of $(0.34 \times 370.6/10.7)$ bps $=$ 12 bps in the five-year corporate default risk yield premium.

To summarize, the empirical results on credit losses and corporate bond risk premia indicate that the effect of inflation volatility on corporate bond spreads acts largely through expected credit losses. On the other hand, the inflation-stock correlation affects corporate bond spreads through both the expected credit loss and the default risk channels and both channels are similarly quantitatively important.

E. Inflation-Indexed Corporate Bonds in Israel

Theory predicts that corporate bond spreads and inflation risk should be unrelated in financial markets with conventionally inflation-indexed liabilities. We study this prediction using Israeli data for the period 2000 to 2010. Israeli government and corporate bonds have conventionally been inflation-indexed since the 1950s (Koninsky (1997)) providing an ideal setting for this placebo test.[28] Moreover, Israeli inflation was low and comparable to the U.S. during 2000 to 2010, so differing findings cannot be attributed to fundamentally different inflation environments.

We construct an index of Israeli corporate bond spreads over maturity-matched government bonds for 2000.Q1 to 2010.Q4. Individual bond yields are from *Bloomberg* and a proprietary data source. We include non-convertible bonds issued by non-financial firms with five to eleven years remaining to maturity. All included corporate bonds are rated A- or higher by the rating agency S&P Maalot or A3 or higher by the rating agency Midroog. Maturity-matched government bond yields are from the Bank of Israel. For a detailed data description see Supplementary Appendix C.4.

In contrast to the findings for nominal corporate bonds, we find no evidence that inflation-indexed corporate bond spreads increase in either inflation volatility or the inflation-stock correlation. On the contrary, Israeli inflation-indexed corporate bond spreads increased from 54 bps to 146 bps over the sample while inflation volatility decreased from 283 bps to 155 bps. At the same time, daily turnover in corporate bonds increased almost tenfold, so liquidity is not a likely explanation for the increase in credit spreads.[29]

We test the relation between Israeli inflation-indexed corporate bond spreads and inflation volatility and the inflation-stock correlation analogously to the baseline empirical results in Table V. Table IX regresses Israeli inflation-indexed corporate log yield spreads onto inflation risk variables and controls as in (38). Due to the limited sample size, we restrict the set of control variables to those included in the model regressions in Table III, and we use Newey-West standard errors with four lags. Including a reduced number of control variables is conservative in that it might bias us against finding zero slope coefficients.

[TABLE IX ABOUT HERE]

Table IX column (5) shows that inflation volatility and the inflation-stock correlation do not enter significantly while controlling for equity volatility, the dividend-price ratio, and inflation and stock return surprises. Inflation volatility enters negatively both for the full sample and for a pre-crisis sample shown in column (6). The inflation-stock correlation's slope estimate is positive but insignificant for the full sample, and it becomes negative for the pre-crisis sample.

While inflation risk does not appear to drive inflation-indexed corporate bond spreads, Israel as a small open economy is especially exposed to international macroeconomic risks. The European debt crisis was likely an important determinant of Israeli corporate bond spreads during our sample, as evidenced by the fact that the Israeli inflation-indexed corporate bond spread is 68% correlated with the log yield spread of 10 year Italian government bonds over German government bonds.[30] Table IX column (7) shows that the regression R^2 increases by 15 percentage points and both the inflation volatility and the inflation-stock correlation enter with negative and insignificant coefficients when we include the Italy-Germany sovereign log yield spread. The role of global risk factors for Israeli corporate bonds underscores the importance of controlling for such factors in our benchmark empirical results. Table V shows that results for nominal corporate bond spreads are robust to flexibly controlling for time-varying global risks with time fixed effects.

Taken together, we find no evidence that Israeli inflation-indexed corporate bond spreads increase in either inflation volatility or the inflation-stock correlation. The evidence from Israeli inflation-indexed corporate bonds supports the view that time-varying risk of debt deflation, rather than omitted variables, drives the positive empirical relation between inflation risk and nominal corporate bond spreads in our benchmark results.

IV. Conclusion

While during the 1970s and 1980s investors and policy makers were concerned about stagflation, the two most recent U.S. recessions have been accompanied by low inflation. This paper argues that uncertainty about the long-run price level and the changing relationship of inflation with the business cycle are major macroeconomic determinants of corporate bond spreads. Recent high inflation cyclicality can help understand the high level of corporate bond spreads.

In a real business cycle model with time-varying inflation risk, inflation persistence generates large effects of inflation risk on credit spreads. Using data on international corporate bond spreads, we provide new evidence that corporate bond investors price the time-varying risk of debt deflation.

Our results have broader implications for the macroeconomic determinants of optimal capital structure of firms and households. While our model only allows for one dimension of capital structure choice, in reality firms and households might adjust to changing inflation risk along a rich number of dimensions. Firms could issue inflation-indexed corporate debt, floating-rate debt, callable debt, or shorter term debt in response to inflation risk. However, each of these adjustments is likely to come at a cost, such as rollover risk (He and Xiong (2012), Acharya, Gale, and Yorulmazer (2011)), short-term variability in real payments (Campbell and Cocco (2003)), or agency costs (Bodie and Taggart (1978)).

The results in this paper highlight the importance of better understanding the macroeconomic and monetary policy determinants of bond and inflation risks. A decomposition of time-varying inflation risk into macroeconomic shocks, such as cost push shocks and shocks to aggregate demand, and time-varying monetary policy, could be of particular interest to central banks around the world.

From a policy point of view, our results indicate that policy makers should take the possibility of debt deflation as seriously as investors appear to do so. Concerns about debt deflation are especially relevant given the potentially important macroeconomic feedback effects of debt deflation (Bernanke and Gertler (1989), Kiyotaki and Moore (1997)) and renewed concerns about a deflationary drop in aggregate demand in the U.S.

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Notes

[1]A number of recent papers on inflation risk premia in government bonds include D'Amico, Kim, and Wei (2009), Christensen, Lopez, and Rudebusch (2010), Haubrich, Pennacchi, and Ritchken (2012), Campbell, Sunderam, and Viceira (2013), Pflueger and Viceira (2011), and Kung (2013).

[2]The *Survey of Professional Forecasters* provides forecasters' average survey probabilities that annual-average over annual-average GDP index inflation will fall into a particular range. Panel A shows the difference between the 90th and the 10th inflation distribution percentiles smoothed over the past eight quarters. Panel B shows the smoothed difference between the 50th and the 10th percentiles. When the lowest probability range receives a weight of more than 10%, we fit a unimodal beta distribution following Engelberg, Manski, and Williams (2009). Supplementary Appendix C.1 provides a detailed variable description.

[3]Hershey, Robert D. Jr., 1982, Inflation hurts, but deflation could be worse, *The New York Times*, April 18.

[4]Bernanke, Ben, 2002, Deflation: Making sure that 'it' doesn't happen here, *Remarks Before the National Economists Club, Washington D.C.*, November 21.

[5]Throughout the paper we refer to the log of the gross yield as the log yield. That is, if we have a bond that yields 3%, we obtain the log yield as $log(1.03) \approx 0.03$. We measure the U.S. credit spread as the difference between the log Moody's Baa long-term yield over the log Aaa long-term yield. Moody's long-term corporate bond yields are based on seasoned bonds with 20 to 30 years remaining to maturity.

[6]See e.g. Duffie and Singleton (1997), Grinblatt (2001), Krishnamurthy (2002), Krishnamurthy and Vissing-Jorgensen (2012), Longstaff (2004), and Feldhutter and Lando (2008).

[7]For simplicity, in Figure 2 both the defaultable and default-free bonds are zero coupon with fixed and equal nominal face values. The representative firm defaults when the real asset value falls below the real face value of liabilities. In default bond holders become the residual claimants on the firm's assets.

[8]It is important for our quantitative results that expected inflation is persistent. The assumption of an exact random walk is primarily for analytical tractability.

[9]The firm never finds it optimal to default in its intermediate period because no debt payments come due during the intermediate period.

[10]See Table IV.

[11]Welch (2004) finds that the mechanistic effects of stock returns can explain about 40% of movements in leverage ratios over a five-year horizon. Baker and Wurgler (2002) find that corporations are likely to raise more equity when their market valuations are relatively higher, and that these effects can explain leverage ten years out. For empirical evidence on sticky leverage, also see Leary and Roberts (2005).

[12]A recovery rate in the range of 40% to 50% is also consistent with the evidence in Cremers, Driessen, and Maenhout (2008), Glover (2011) and Coval, Jurek, and Stafford (2009).

[13]We simulate 250 runs of length 100. Both model and empirical equity returns are defined as ten-year log nominal equity returns in excess of the continuously compounded ten-year nominal interest rate.

[14]To ensure that regressors are never perfectly collinear, we add small measurement errors to the inflation shock and inflation risk variables. The standard deviations of the model measurement errors are approximately 2% of the standard deviations of the underlying parameters.

[15]Figure 4 plots average seasoned credit spreads for different inflation risk regimes against lagged stock returns and inflation surprises. We average credit spreads within stock return and inflation shock quintiles and within inflation risk regimes. We simulate 500 runs of length 100. We use quintile cutoffs from Model 2 for both Models 1 and 2, because inflation quintiles in Model 1 are not well defined.

[16]According to *GFD*, the original sources for government bond yields and T-bill rates are the Reserve Bank of Australia, Bank of Canada, Deutsche Bundesbank, Bank of Japan, Bank of England, and Federal Reserve Bank. The original inflation sources are the Australian Bureau of Statistics, Statistics Canada, German Statistisches Bundesamt, Japanese Statistics Bureau, UK Central Statistical Office, and U.S. Bureau of Labor Statistics. Quarterly GDP in millions of national currency, volume estimates, OECD reference year, annual levels, seasonally adjusted is from *OECD Stat*. Stock returns correspond to the following equity indexes: Australia ASX Accumulation Index, Canada S&P/TSX-300 Total Return Index, Germany CDAX Total Return Index, Japan Topix Total Return Index, United Kingdom FTSE All-Share Return Index, and United States S&P 500 Total Return Index. We are extremely grateful to Yoichi Matsubayashi for providing us with Japanese corporate bond yield data. Durations are estimated from bond maturities, assuming that bonds sell at par following Campbell, Lo, and MacKinlay (1997), p. 408. For a description of Moody's corporate bond indexes, see http://credittrends.moodys.com/chartroom.asp?r=3. Table B.1 in the Supplementary Appendix lists further details on the corporate bond data sources and durations.

[17]Data for the U.S. and Canada is from *Compustat North America* and the *Center for Research in*

Security Prices (*CRSP*). Data for all other countries is from *Compustat Global*. We divide annual book debt values from the previous year end by the sum of the same book debt and quarterly market equity. Following Baker and Wurgler (2002), we define book debt as the sum of total liabilities and preferred stock minus deferred taxes and convertible debt. When preferred stock is missing, we use the redemption value of preferred stock. Corporate bond yield indexes, such as Moody's long-term yield indexes, weight observations equally, and therefore we control for equal-weighted market leverage.

[18]We obtain U.S. stock returns from *CRSP*, Canadian stock returns from *Datastream*, and all other country stock returns from *Compustat Global*. Industries are defined according to GIC classification codes.

[19]For a given MSCI index, the dividend yield is computed as the market-value weighted average dividend yield of all constituents. The dividend yield for an individual stock is based on its most recent annualized dividend rate (i.e., dividends per share) divided by the current share price.

[20]Bond volatility and the bond-stock correlation report the annualized standard deviation of changes in long-term nominal government bond log yields and the correlation between changes in nominal government bond log yields and log stock returns, respectively. These measures are also equal to the volatility of government bond log returns scaled by the bond duration and the negative of the correlation between government bond log returns and log stock returns, where bond returns are approximated using changes in yields.

[21]Using bond-market derived measures, Wright (2011) argues that inflation cyclicality has increased since 1990 in most developed countries.

[22]We use the sum of log inflation surprises and log real stock return surprises over the past three

years and over the past quarter, quarterly and three-year log real GDP growth, and the three-year change in unemployment.

[23]For an analysis of the Japanese corporate bonds market, see Hattori, Koyama, and Yonetani (2001), who argue that the default risk of the individual issuer is the most important determinant of corporate bond spreads in Japan after 1997. Reserve Bank of Australia (2001) provides an overview of the Australian corporate bond market. Galati and Tsatsaronis (2003) and De Bondt and Lichtenberger (2003) study Euro corporate bonds during the Euro introduction.

[24]We obtain the three-month BBA LIBOR Rate from *Bloomberg* as "US0003m Index" available starting 1971.Q1.

[25]We obtain the off-the-run bond yield by pricing the on-the-run bond cash flows with the off-the-run bond yield curve of Gurkaynak, Sack, and Wright (2007). On-the-run bond yields and issue characteristics are from the monthly *CRSP* Treasury master file. The off-the-run spread is the difference between the off-the-run and on-the-run bond yields, both continuously compounded. The Supplementary Appendix provides a detailed variable description.

[26]We use the *Moody's Corporate Default Risk Service* database to compute loss rates corresponding as closely as possible to the Moody's long-term Baa corporate bond yield. We compute annualized issuer-weighted loss rates as the product of average default rates times average loss given default. We consider U.S. domiciled firms in the industrial and public utilities sectors with a senior long-term Baa rating. $loss_{US,t\rightarrow t+n}$ includes all defaults of firms that were rated Baa in year t and defaulted in years $t+1$ through $t+n$. Because of the lag between credit loss rates and inflation risk variables, the five year default forecasts effectively only use data on inflation volatility and the inflation-stock correlation until 2005.

[27]We obtain long-term corporate and government bond return indexes from *Ibbotson Associates*.

[28]The proportion of non-linked corporate bond issuances has increased over time, but the majority of corporate debt raised on the Tel Aviv Stock Exchange in 2007, 2008, and 2009 was still CPI-linked (Tel-Aviv Stock Exchange (2009)).

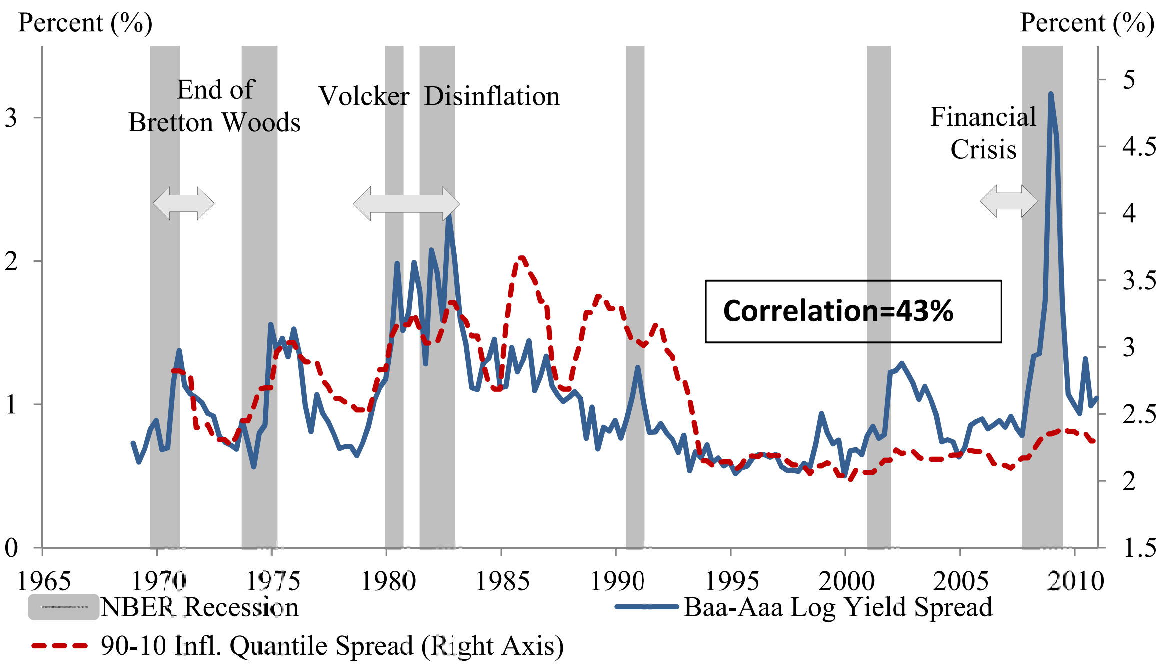
[29]Annual statistics from the Tel Aviv Stock Exchange http://www.tase.co.il/Eng/Statistics/AnnualTables/Pages/Annual_Tables.aspx.

[30]Italian and German benchmark yields from *Datastream* (TRBD10T, TRIT10T).

Figure 1: U.S. Credit Spreads and Survey Inflation Uncertainty

Average log yield spread on Moody's long-term Baa-rated corporate bonds over long-term Aaa-rated corporate bonds and survey inflation uncertainty. The Survey of Professional Forecasters provides forecasters' average survey probabilities that annual-average over annual-average GDP index inflation will fall into a particular range. We interpolate the cumulative density function linearly and smooth quantiles over the past eight quarters. When the lowest inflation range receives a weight of more than 10%, we infer quantiles from a fitted beta distribution following Engelberg, Manski, and Williams (2009). Supplementary Appendix C.1 provides a detailed variable description. Panel A shows the smoothed difference between the 90th and the 10th inflation percentiles. Panel B shows the smoothed difference between the 50th and the 10th percentiles.

Panel A: Inflation Uncertainty



Panel B: Lower Tail Inflation Uncertainty

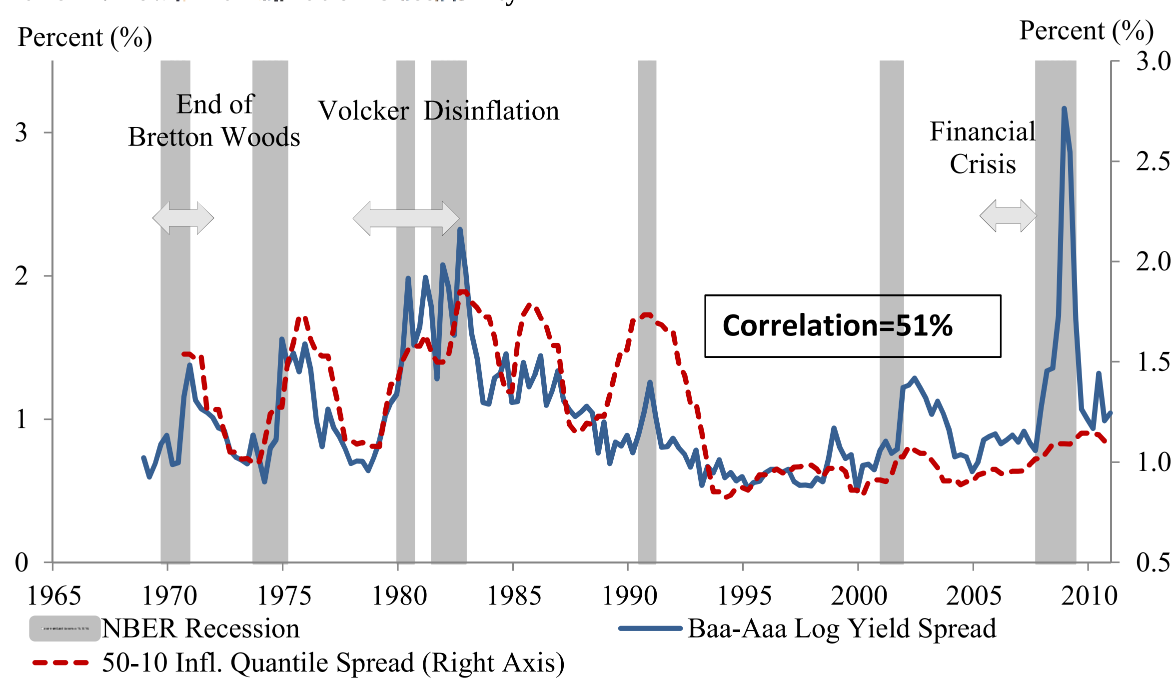


Figure 2: Contingent Claim Payoff Profiles

Illustrative conditional expected real payoffs on nominal corporate and default-free bonds for different inflation risk scenarios. Both bonds are zero coupon with nominal face values of 1. We assume that the representative firm defaults when the real asset value is less than the real face value of the bond, and that bond holders become residual claimants in default. Let P denote the price level, V the real asset value, and I() the indicator function. In Panel A, there is no uncertainty about the price level. In Panel B, inflation surprises are independent from V. In Panels C and D, inflation surprises are perfectly positively or negatively correlated with V. The conditional expected payoff on the nominal default-free bond is E[1/P|V], and on the corporate bond is E[V I(VP<1)+(1/P) I(VP≥1)|V]. The detailed numerical implementation is discussed in the Supplementary Appendix A.

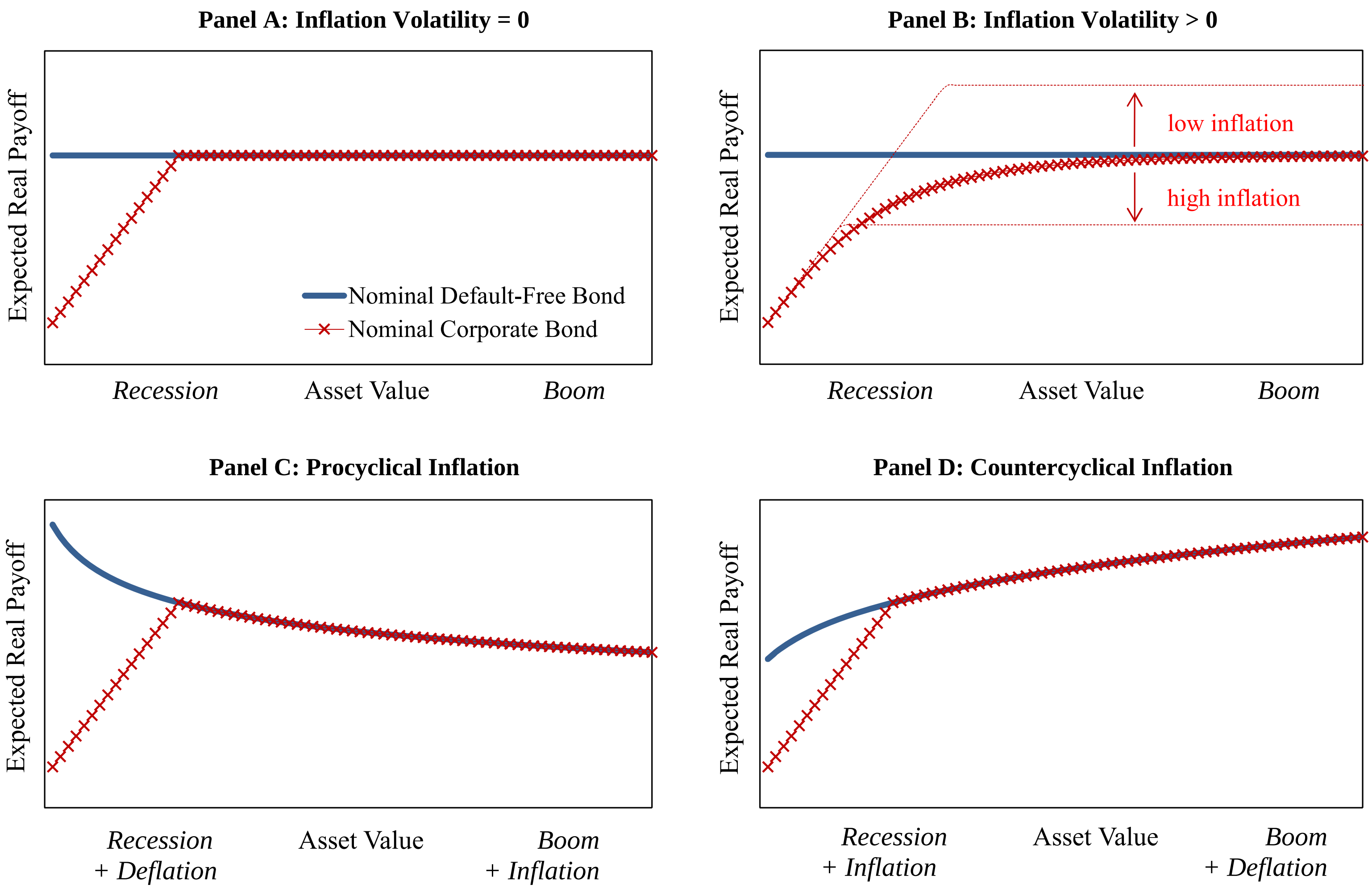


Figure 3: Timeline of Firm i Cohort t

t	$t+1$	$t+2$
· Young firm	· Seasoned firm	· Old firm
· Choose nominal debt $B^{\$}_{t}$	· Real aggregate TFP shock ε^{TFP}_{t+1}	· Real aggregate TFP shock ε^{TFP}_{t+2}
· Purchase capital K^{y}_{t+1}	· Nominal aggregate shock ε^{π}_{t+1}	· Nominal aggregate shock ε^{π}_{t+2}
· New credit spreads	· Real idiosyncratic shock $a^{i,1}_{t+1}$	· Real idiosyncratic shock $a^{i,2}_{t+2}$
	· Seasoned credit spreads	· Default decision
		· Liquidating dividend

Figure 4: Asymmetric Model Predictions

Simulated average seasoned corporate log yield spreads versus stock returns and inflation shocks. Low and high inflation volatility corresponds to 0% p.a. and 2% p.a., while inflation is uncorrelated with TFP shocks (Model 1). High and low inflation-TFP correlation corresponds to 0.6 and -0.6, while inflation volatility is constant at 1% p.a. (Model 2). We average credit spreads within real stock return quintiles and inflation shock quintiles over 500 simulations of length 100. Quintile cutoffs in all panels are based on the simulated Model 2 stock return and inflation shock distributions. We normalize credit spreads to zero in the middle quintile of each panel and show a horizontal line at 0.

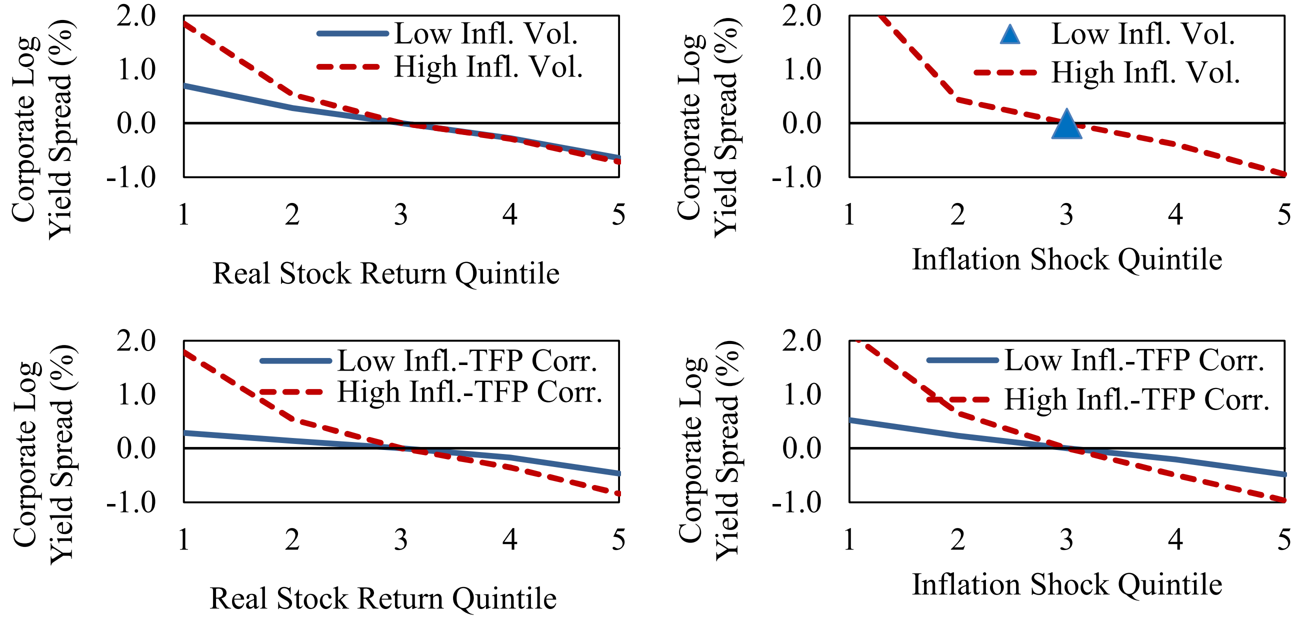


Figure 5: International Credit Spreads and Inflation Volatility

This figure shows the comovement of quarterly credit spreads (solid) and inflation volatility (dashed) for Australia, Canada, Germany, Japan, the U.K., and the U.S. Credit spreads are computed as investment grade corporate bond index log yields in excess of duration-matched nominal government bond log yields, except for the U.S. credit spread, which is the Moody's Baa minus Aaa log yield spread. Inflation volatility is computed using a three-year backward-looking window of quarterly inflation surprises.

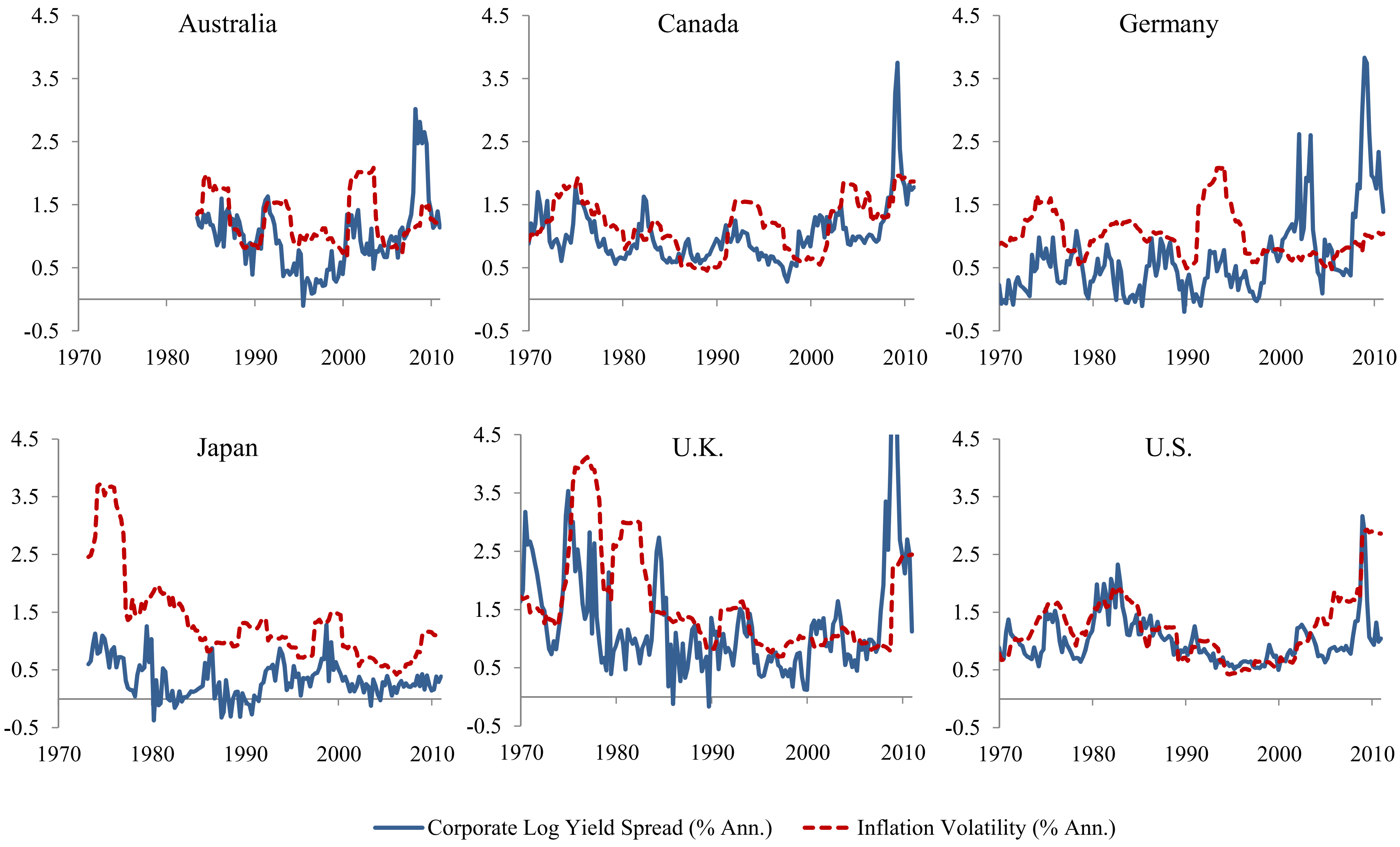


Figure 6: International Credit Spreads and Inflation-Stock Correlation

This figure shows the comovement of quarterly credit spreads (solid) and the inflation-stock correlation (dashed) for Australia, Canada, Germany, Japan, the U.K., and the U.S. Credit spreads are computed as investment grade corporate bond index log yields in excess of duration-matched nominal government bond log yields, except for the U.S. credit spread, which is the Moody's Baa minus Aaa log yield spread. The inflation-stock correlation is computed using a three-year backward-looking window of quarterly surprises in inflation and stock returns, as described in Table IV.

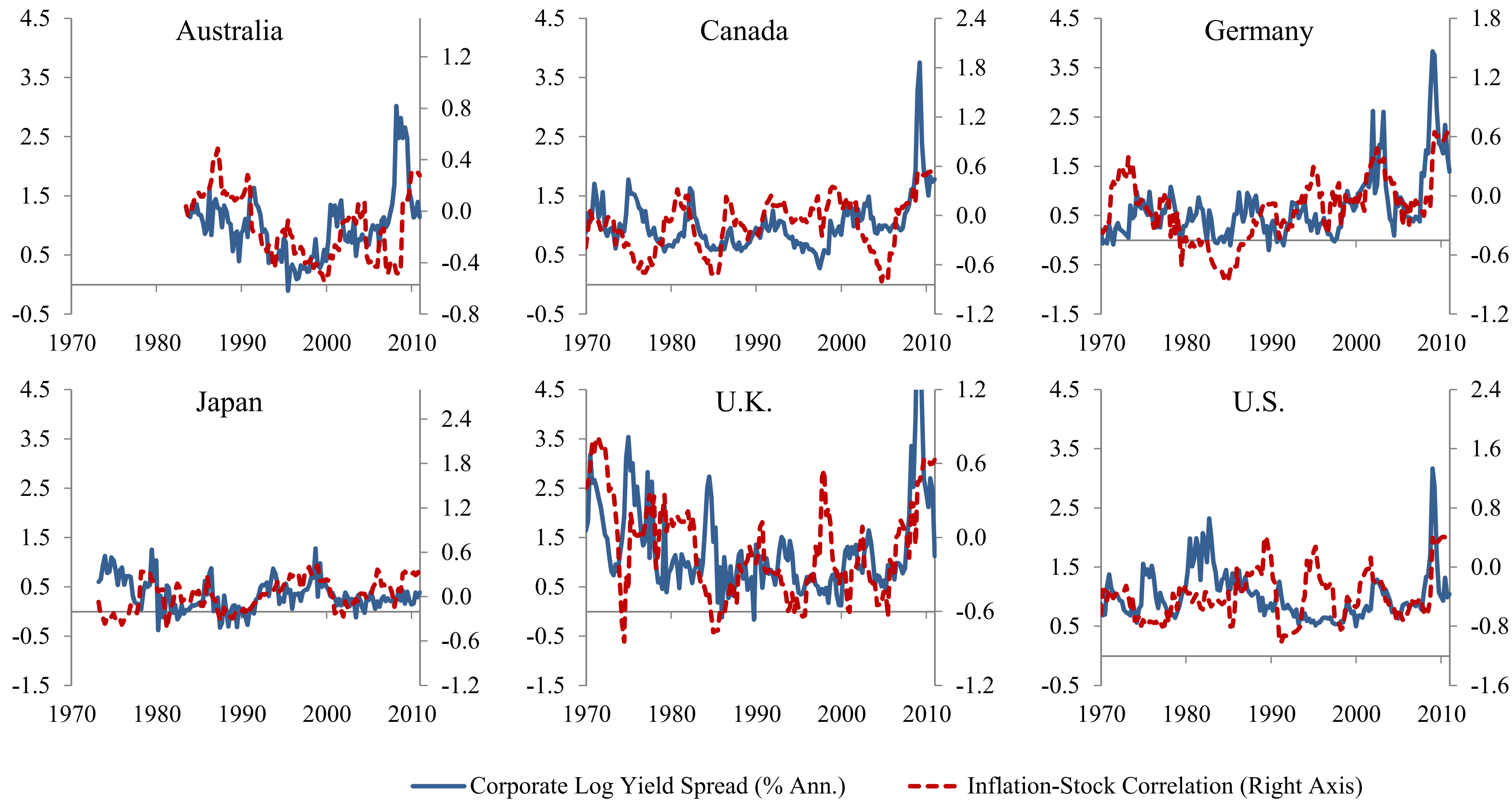


Figure 7: Empirical Credit Spreads, Stock Returns and Inflation Shocks

International empirical credit spreads versus stock returns and inflation shocks. The top left panel averages credit spreads within quintiles of lagged three-year real stock returns and two inflation volatility regimes. The other panels are constructed similarly by sorting credit spreads into quintiles of lagged three-year inflation shocks and two inflation-stock return correlation regimes, as indicated. Inflation risk regimes are defined relative to the country-specific median. We normalize credit spreads to zero in the middle quintile of each panel and show a horizontal line at 0.

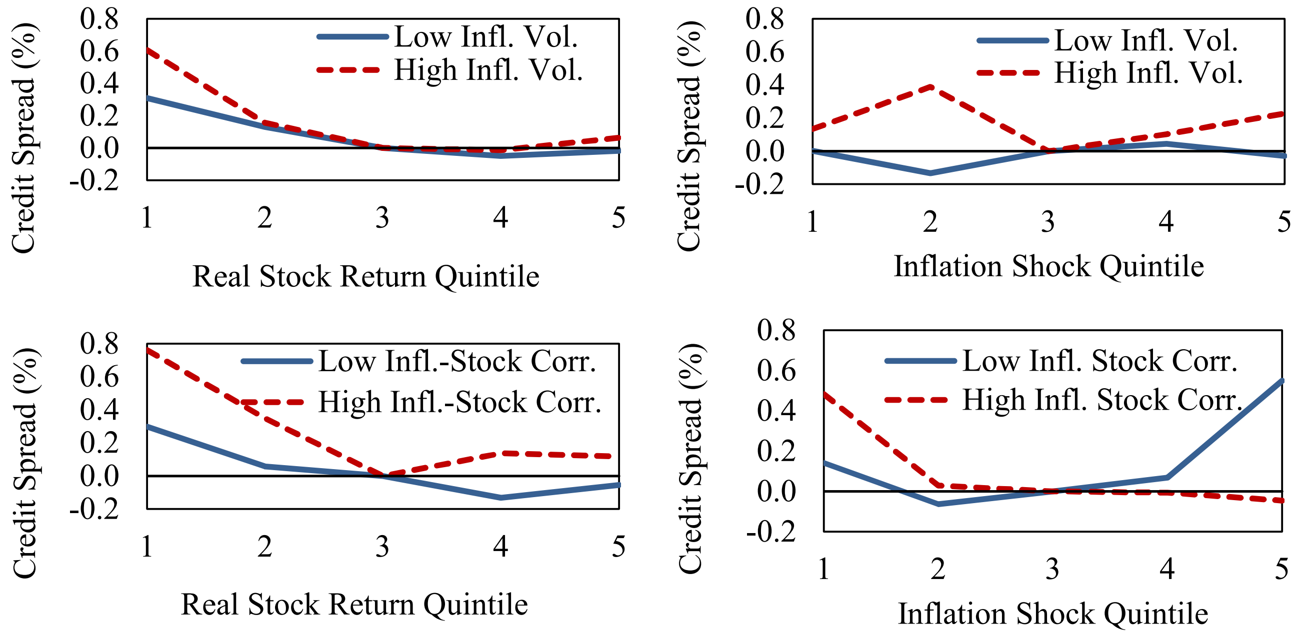


Table I: Model Parameters

We show model parameters used in our calibrations. * denotes per annum units. Annualized inflation volatility is the standard deviation of a one-year inflation shock. p(X→X) denotes the probability that the state at time t+1 will be X conditional on the time t state being X.

General Parameters		
Period length		5 years
Discount rate	β	3%*
Risk aversion	γ	10
Capital share	α	0.33
Depreciation	δ	8%*
Trend growth	μ	2.8%*
Volatility of TFP shock	σ	26%*
Recovery rate	θ	0.40
Tax benefit of debt	χ	1.40
Idiosyncratic volatility	σ^{id}	17%*

Model 1: Time-Varying Inflation Volatility		
Inflation-TFP correlation	ρ^{π}	0.00
High inflation volatility	$\sigma^{\pi,H}$	2%*
Low inflation volatility	$\sigma^{\pi,L}$	0%*
Persistence of $\sigma^{\pi,H}$	$p(\sigma^{\pi,H}\rightarrow\sigma^{\pi,H})$	0.60
Persistence of $\sigma^{\pi,L}$	$p(\sigma^{\pi,L}\rightarrow\sigma^{\pi,L})$	0.80

Model 2: Time-Varying Inflation TFP Correlation		
Inflation volatility	σ^{π}	1%*
High inflation-TFP correlation	$\rho^{\pi,H}$	0.60
Low inflation-TFP correlation	$\rho^{\pi,L}$	-0.60
Persistence of $\rho^{\pi,H}$	$p(\rho^{\pi,H}\rightarrow\rho^{\pi,H})$	0.70
Persistence of $\rho^{\pi,L}$	$p(\rho^{\pi,L}\rightarrow\rho^{\pi,L})$	0.70

Table II: Empirical and Model Moments

We compare simulated moments of calibrated Models 1 and 2 with empirical U.S. moments estimated between 1970-2009. Equity volatility is the standard deviation of 10 year log nominal equity returns in excess of the 10 year log nominal government yield. Firm volatility is the standard deviation of idiosyncratic 10 year log nominal stock returns for non-defaulted firms. The equity premium is the average 10 year log nominal equity return in excess of the 10 year log nominal government yield (adjusted for Jensen's inequality). The average seasoned credit spread is computed as the average Moody's Baa- Aaa corporate log yield spread. We use the historical U.S. 10-year investment grade bond default probability 1970-2001 reported by Almeida and Philippon (2007). We report the aggregated book leverage ratio, computed as long-term debt plus short-term debt divided by total assets from Compustat. For a detailed description of model moments see Supplementary Appendix E.

	Empirical U.S. 1970-2009	Model 1 Time-Varying σ^{π}	Model 2 Time-Varying ρ^{π}
Equity volatility (% Ann.)	18.4%	18.5%	18.0%
Firm volatility (% Ann.)	47.2%	29.3%	29.0%
Equity premium (% Ann.)	2.90%	7.82%	7.83%
$y_t^{gov,10} - \pi_t$	2.50%	2.80%	2.72%
$y_t^{gov,10} - y_t^{gov,5}$	0.25%	1.16%	1.08%
New corporate log yield spread		1.18%	1.23%
Seasoned corporate log yield spread	1.01%	1.64%	1.53%
Default probability	0.52%	0.45%	0.40%
Leverage	25%	41%	40%

Table III: Model Credit Spread Regressions

We estimate the sensitivity of model seasoned corporate log yield spreads to inflation volatility and the inflation-stock correlation in the calibrated models. In Panel A, inflation volatility switches between 0% p.a. and 2% p.a., and the inflation-TFP correlation is zero. In Panel B, inflation volatility is constant at 1% p.a., and the inflation-TFP correlation switches between -0.6 and 0.6. We use log seasoned equity returns and one-period changes in log inflation expectations as control variables. We also control for the dividend-price ratio, defined as the expected return on seasoned equity. The inflation-stock correlation is defined as the correlation between log seasoned equity returns and shocks to log inflation expectations. Equity volatility is defined as the standard deviation of log real returns on seasoned equity.

Panel A: Time-Varying Inflation Volatility (Model 1)

$$spread_t^{seas} = \lambda_1^0 + \lambda_1^{\sigma^\pi}\sigma_t^\pi + \lambda_1^{\sigma^{eq}}\sigma_t^{eq} + \lambda_1^{DP} DP_t^{seas} + \lambda_1^{eq} r_t^{eq} + \lambda_1^\pi \varepsilon_t^\pi + \eta_{1,t}$$

Seas. corporate log yield spread (% Ann.)	(1)	(2)	(3)	(4)
Inflation volatility (Ann.)		27.10		27.13
		(9.37)		(8.51)
Equity volatility (Ann.)			8.69	2.27
			(6.67)	(6.96)
Dividend-price ratio (Ann.)			17.51	30.16
			(14.12)	(14.63)
Equity return	-1.36	-1.36	-1.71	-1.45
	(0.21)	(0.21)	(0.34)	(0.34)
Inflation shock	-10.75	-10.76	-10.58	-10.70
	(2.39)	(2.16)	(2.30)	(2.11)
Constant	2.27	2.09	1.03	1.29
	(0.12)	(0.09)	(0.50)	(0.50)
R^2	0.75	0.79	0.81	0.85

Panel B: Time-Varying Inflation-TFP Correlation (Model 2)

$$spread_t^{seas} = \lambda_2^0 + \lambda_2^{\rho^\pi}\rho_t^\pi + \lambda_2^{\sigma^{eq}}\sigma_t^{eq} + \lambda_2^{DP} DP_t^{seas} + \lambda_2^{eq} r_t^{eq} + \lambda_2^\pi \varepsilon_t^\pi + \eta_{2,t}$$

Seas. corporate log yield spread (% Ann.)	(1)	(2)	(3)	(4)
Inflation-stock correlation		26.62		19.70
		(9.75)		(11.94)
Equity volatility (Ann.)			10.84	4.91
			(4.19)	(6.12)
Dividend-price ratio (Ann.)			12.96	24.00
			(10.53)	(14.17)
Equity return	-1.41	-1.40	-1.85	-1.61
	(0.21)	(0.20)	(0.26)	(0.32)
Inflation shock	-9.29	-9.31	-9.11	-9.20
	(1.14)	(1.09)	(0.97)	(0.96)
Constant	2.18	2.15	0.83	1.21
	(0.11)	(0.11)	(0.31)	(0.42)
R^2	0.72	0.74	0.80	0.81

Table IV: Summary Statistics

We report summary statistics for the spread of investment grade corporate bond log yields in excess of duration-matched nominal government bond log yields. For the U.S., we show the spread between Moody's Baa long-term log yields over Moody's Aaa long-term log yields. Corporate bond yields from the Economist (Australia), Bank of Canada and Datastream (Canada), Bundesbank (Germany), Nikkei Corporate Bond Index (Japan), Financial Times and the Economist (U.K.), and Moody's (U.S.). Average corporate bond durations are estimated assuming that bonds sell at par (Campbell, Lo, and MacKinlay (1997)). The annualized standard deviation of inflation surprises, the inflation-stock correlation, and the annualized standard deviation of real stock return surprises use a moving three-year window of quarterly inflation and stock return surprises. Inflation surprises are residuals from regressing quarterly log inflation onto its own four lags, the lagged log T-bill, and seasonal dummies. Stock return surprises are residuals from regressing the quarterly log real stock return onto its own lag. Dividend-price ratios from MSCI. Panel B reports additional control variables only available for a shorter time period. Idiosyncratic volatility is the standard deviation of daily firm stock returns in excess of market and sector returns using GIC sector classifications (Campbell et al. (2001)). Equal-weighted market leverage from Compustat. Bond volatility is the annualized standard deviation of daily or weekly changes in nominal government bond log yields over the past quarter. The bond-stock correlation reports the correlation between real log stock returns and changes in nominal government bond log yields over the past quarter.

Panel A: Long Sample Period Variables

		Australia	Canada	Germany	Japan	U.K.	U.S.
Start date		1983.Q3	1969.Q4	1969.Q4	1973.Q1	1969.Q4	1969.Q4
End date		2010.Q2	2010.Q4	2010.Q4	2010.Q2	2010.Q4	2010.Q4
Credit spread (%)	mean	0.99	1.02	0.65	0.33	1.28	1.02
	std	0.56	0.45	0.67	0.32	0.98	0.42
	min	-0.10	0.28	-0.20	-0.38	-0.16	0.50
	max	3.02	3.76	3.83	1.28	6.25	3.17
Avg. corp. bond duration (years)		6.9	10.1	5.1	8.2	8.5	10.7
Inflation vol. (%, Ann.)	mean	1.26	1.19	1.01	1.33	1.61	1.23
	std	0.40	0.43	0.36	0.77	0.88	0.58
	min	0.70	0.45	0.48	0.42	0.70	0.42
	max	2.09	1.97	2.11	3.72	4.12	2.93
Inflation-stock correl.	mean	-0.09	-0.03	-0.15	0.00	-0.12	-0.26
	std	0.31	0.34	0.32	0.27	0.31	0.34
	min	-0.61	-0.77	-0.83	-0.56	-0.70	-0.90
	max	0.64	0.66	0.63	0.51	0.59	0.55
Equity Vol. (%, Ann.)	mean	16.72	16.19	19.50	19.61	18.57	16.06
	std	8.35	5.55	7.62	6.32	8.09	5.34
	min	6.72	7.87	7.80	5.51	5.85	5.66
	max	37.57	27.40	40.20	36.04	44.41	27.99
Div.-price ratio (%, Ann.)	mean	3.86	2.96	3.39	1.30	4.26	3.12
	std	0.80	1.00	1.12	0.66	1.24	1.32
	min	2.60	0.99	1.67	0.43	2.11	1.14
	max	6.95	5.67	6.20	2.86	10.46	6.14

Panel B: Shorter Sample Period Variables

		Australia	Canada	Germany	Japan	U.K.	U.S.
Start date		1989.Q1	1989.Q1	1990.Q1	1989.Q1	1989.Q1	1989.Q1
End date		2010.Q2	2010.Q2	2010.Q2	2010.Q2	2010.Q2	2010.Q2
Bond vol. (%, Ann.)	mean	0.80	0.66	0.54	0.49	0.66	0.72
	std	0.22	0.18	0.17	0.20	0.21	0.22
	min	0.42	0.28	0.28	0.19	0.30	0.40
	max	1.62	1.32	0.97	1.18	1.42	1.54
Bond-stock correl.	mean	-0.04	0.00	-0.09	0.11	-0.03	-0.04
	std	0.35	0.32	0.39	0.31	0.41	0.42
	min	-0.65	-0.62	-0.84	-0.69	-0.80	-0.77
	max	0.78	0.68	0.72	0.64	0.72	0.77
Idiosync. vol. (%, Ann.)	mean	22.23	26.80	26.24	31.28	18.28	25.95
	std	12.03	5.20	9.02	7.46	12.36	7.61
	min	5.02	19.69	15.91	19.08	4.04	16.26
	max	57.68	54.67	54.95	58.00	52.75	50.39
Equal-Weighted Mkt.	mean	17.89	22.58	41.23	34.28	21.45	23.11
Leverage (%)	std	6.25	6.11	13.51	6.69	3.94	3.91
	min	8.69	12.70	21.72	19.59	13.84	16.84
	max	40.76	35.53	63.12	47.40	31.67	33.67

Table V: International Credit Spreads and Inflation Risk (1969.Q4-2010.Q4)

Quarterly pooled regressions of Australia, Canada, Germany, Japan, U.K., and U.S. corporate log yield spreads (% Ann.) against inflation volatility, the inflation-stock correlation, and control variables. We report Driscoll and Kraay (1998) standard errors accounting for cross-country correlation and 16 lags. All regressions contain country fixed effects. The residual R^2 reflects explanatory power in excess of fixed effects. Japan data starts in 1973.Q1. Australia data starts in 1983.Q3. Variables are constructed as described in Table IV. * and ** denote significance at the 5% and 1% levels, respectively.

$$spread_{i,t} = \lambda_i^0 + \lambda^{\sigma^\pi}\sigma^\pi_{i,t} + \lambda^{\rho^\pi}\rho^\pi_{i,t} + \lambda^{\sigma^{eq}}\sigma^{eq}_{i,t} + \lambda^{DP}DP_{i,t} + \Lambda \times X_{i,t} + \eta_{i,t}$$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Inflation risk									
Inflation volatility (Ann.)		29.71**	28.04**		24.61**	12.49**	15.09**	22.94**	22.76**
		(8.36)	(6.96)		(6.97)	(4.30)	(4.50)	(6.22)	(5.66)
Inflation-stock correlation			40.42**		42.37**	39.99**	27.80**	44.88**	26.81**
			(9.10)		(10.22)	(8.62)	(9.65)	(7.66)	(3.94)
Real uncertainty and other control variables									
Equity volatility (Ann.)				1.26	0.86	1.52*	1.35*	1.62*	-0.18
				(0.86)	(0.88)	(0.59)	(0.66)	(0.62)	(0.85)
Dividend-price ratio (Ann.)				8.68*	8.41	14.65**	4.65	26.00**	28.77**
				(4.32)	(4.50)	(5.28)	(3.43)	(7.42)	(10.22)
GDP vol.								6.77	
								(4.68)	
Log T-bill								-11.78**	
								(3.46)	
Log yield curve slope								-9.64*	
								(4.36)	
Idiosyncratic volatility (Ann.)									0.87
									(0.58)
Leverage									-1.19**
									(0.44)
Bond volatility (Ann.)									56.21*
									(23.28)
Bond-stock correlation									71.35**
									(19.66)
Business cycle and inflation shock variables (Logs)									
3-Year inflation shock	2.27	-0.98	-0.89	1.02	-1.69	-2.29*	0.79	-1.04	-3.54
	(1.90)	(1.95)	(1.72)	(1.88)	(1.88)	(1.13)	(1.23)	(1.51)	(1.80)
3-Year real stock return	-0.36**	-0.36**	-0.32*	-0.20	-0.19	0.04	-0.10	0.11	0.01
	(0.12)	(0.12)	(0.12)	(0.11)	(0.11)	(0.14)	(0.10)	(0.12)	(0.10)
3-Year GDP growth	-2.58	-2.51*	-1.32	-2.96*	-1.66	-0.49	-0.41	0.68	0.34
	(1.31)	(1.07)	(0.85)	(1.41)	(0.91)	(1.37)	(0.74)	(0.70)	(1.14)
3-Year change unemployment	-1.82	-5.51	-3.03	-3.04	-3.72	-1.24	1.08	0.07	0.48
	(3.39)	(3.81)	(3.40)	(3.75)	(3.72)	(2.12)	(2.02)	(2.28)	(2.43)
Quarterly inflation shock	-5.67	-4.20	-5.01	-4.93	-4.51	0.91	-0.37	-6.26*	-3.89
	(3.99)	(3.62)	(3.65)	(3.74)	(3.35)	(2.11)	(1.62)	(2.91)	(2.03)
Quarterly real stock return	-0.47	-0.50	-0.51	-0.44	-0.48	0.52	-0.02	-0.52	-0.51
	(0.43)	(0.43)	(0.43)	(0.43)	(0.43)	(0.28)	(0.22)	(0.36)	(0.30)
Quarterly GDP growth	-11.00*	-10.87*	-11.13*	-10.50*	-10.44*	-2.81	-4.98**	-10.08**	-15.33**
	(5.54)	(5.25)	(5.00)	(5.02)	(4.40)	(2.39)	(1.63)	(3.43)	(3.42)
Residual R^2	0.19	0.25	0.28	0.22	0.30	0.30	0.27	0.41	0.55
Time fixed effects						Yes			
Period	Full	Full	Full	Full	Full	Full	69.Q4-07.Q4	Full	89.Q1-09.Q4

Table VI: U.S. Credit Spreads and Inflation Risk (1972.Q1-2010.Q4)

We regress quarterly U.S. Baa-Aaa Moody's log yield spreads against inflation volatility, the inflation-stock correlation, and control variables. We obtain the off-the-run bond yield by pricing the on-the-run bond cash flows with the off-the-run bond yield curve of Gurkaynak, Sack, and Wright (2007). On-the-run bond yields and issue characteristics are from the monthly CRSP Treasury master file. The off-the-run spread is the difference between the off-the-run and on-the-run bond yields, both continuously compounded. The three-month BBA LIBOR Rate is from Bloomberg (US0003m Index). All other variables are as described in Table IV. We report Newey-West standard errors with 16 lags in parentheses. * and ** denote significance at the 5% and 1% levels, respectively.

$$spread_{US,t} = \lambda^0_{US} + \lambda^{\sigma^\pi}\sigma^\pi_{US,t} + \lambda^{\rho^\pi}\rho^\pi_{US,t} + \lambda^{\sigma^{eq}}\sigma^{eq}_{US,t} + \lambda^{DP}DP_{US,t} + \Lambda \times X_{US,t} + \eta_{US,t}$$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Inflation risk									
Inflation volatility (Ann.)		40.02**	39.93**		35.28**	47.36**	38.38**	30.75**	33.48**
		(10.75)	(10.39)		(7.02)	(6.35)	(7.56)	(6.25)	(4.94)
Inflation-stock correlation			0.83		0.13	27.80**	0.47	-0.49	2.48
			(16.23)		(12.35)	(9.79)	(12.57)	(9.75)	(10.32)
Real uncertainty and other control variables									
Idiosyncratic volatility (Ann.)				1.96*	2.27**	1.56**	2.20**	1.47*	0.79*
				(0.76)	(0.75)	(0.51)	(0.81)	(0.73)	(0.38)
Dividend-price ratio (Ann.)				16.28**	13.85**	10.58**	10.17	10.43**	7.89*
				(2.59)	(2.15)	(1.64)	(6.15)	(1.86)	(3.13)
GDP vol.							-3.91		
							(6.83)		
Log T-bill							2.91		
							(3.37)		
Log yield curve slope							2.35		
							(4.47)		
Equity volatility (Ann.)									0.02
									(0.29)
Leverage									0.96
									(0.59)
Bond volatility (Ann.)									50.00**
									(7.74)
Bond-stock correlation									9.48
									(5.89)
Liquidity variables									
Treasury off-the-run spread								48.99	
								(39.41)	
Eurodollar over T-bill								12.51**	
								(3.60)	
Business cycle and inflation shock variables (Logs)									
3-Year inflation shock	-0.08	-0.49	-0.45	-2.01	-1.87	-0.91	-1.97	-2.72	-2.49*
	(3.95)	(2.95)	(3.24)	(2.41)	(2.10)	(1.81)	(2.24)	(1.96)	(1.19)
3-Year real stock return	-0.26	-0.14	-0.13	-0.30	-0.21	-0.04	-0.28	-0.31	-0.14
	(0.26)	(0.21)	(0.24)	(0.17)	(0.22)	(0.17)	(0.21)	(0.20)	(0.11)
3-Year GDP growth	-0.45	2.55	2.57	-3.13	-0.67	1.36	0.06	-0.54	0.22
	(2.44)	(1.93)	(2.00)	(3.17)	(2.10)	(1.83)	(2.51)	(1.80)	(1.64)
3-Year change unemployment	4.53	4.13	4.23	-0.34	-0.96	6.53*	0.31	-0.29	0.64
	(4.76)	(4.23)	(5.37)	(5.49)	(4.50)	(2.51)	(5.34)	(3.64)	(4.52)
Quarterly inflation shock	-16.72**	-17.88**	-17.89**	-10.84**	-11.64**	-9.15*	-11.71**	-10.97**	-10.85**
	(4.18)	(4.63)	(4.56)	(3.02)	(3.93)	(4.34)	(3.93)	(3.89)	(2.97)
Quarterly real stock return	-0.18	-0.13	-0.13	0.29	0.40	0.69**	0.42	0.43	0.32
	(0.48)	(0.40)	(0.39)	(0.39)	(0.27)	(0.17)	(0.29)	(0.24)	(0.36)
Quarterly GDP growth	-12.62	-12.22*	-12.22*	-7.22	-6.06	-5.71	-7.00	-7.20	-3.91
	(6.51)	(5.88)	(5.88)	(5.20)	(4.38)	(3.72)	(4.37)	(4.03)	(3.81)
R^2	0.38	0.54	0.54	0.61	0.73	0.75	0.73	0.76	0.82
Period	Full	Full	Full	Full	Full	72.Q1-07.Q4	Full	Full	72.Q1-09.Q4

Table VII: Predicting U.S. Baa Credit Loss Rates (1969-2010)

We regress annual data on annualized issuer-weighted credit loss rates of Baa-rated U.S. issuers in the industrial and public utility sectors onto lagged end-of-year inflation volatility, the inflation-stock correlation, and control variables. Loss rates are calculated as the product of default rates and loss given default based on post default trading prices. The n-year loss rate in-year t includes all defaults of firms with a senior long-term Baa rating in year t and at least one default during years t+1 through t+n. Our data source is the Moody's default risk database. We report Newey-West standard errors with 6 lags. Variables are constructed as described in Table IV. * and ** denote significance at the 5% and 1% levels, respectively.

$$loss_{US,t\rightarrow t+n} = \lambda^0_{US} + \lambda^{\sigma^\pi}\sigma^\pi_{US,t} + \lambda^{\rho^\pi}\rho^\pi_{US,t} + \lambda^{\sigma^{eq}}\sigma^{eq}_{US,t} + \lambda^{DP}DP_{US,t} + \Lambda \times X_{US,t} + \eta_{US,t}$$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Horizon n (Years)	1	2	3	4	5	1	2	3	4	3
Inflation risk										
Inflation volatility (Ann.)	2.66	13.89*	19.34**	16.97**	17.31**	-0.61	6.24	16.53**	14.96*	16.97
	(4.89)	(5.69)	(2.71)	(3.61)	(5.58)	(4.43)	(5.32)	(3.79)	(6.09)	(10.32)
Inflation-stock correlation	7.52	11.74**	21.83**	17.05**	18.47**	1.57	5.69	17.10*	11.32	13.06
	(6.84)	(3.71)	(7.85)	(5.51)	(6.52)	(6.61)	(3.25)	(6.60)	(7.00)	(6.46)
Real uncertainty and other control variables										
Idiosyncratic volatility (Ann.)	0.19	0.51*	0.62*	0.52*	0.20	-0.21	0.09	0.16	-0.16	-0.43
	(0.36)	(0.23)	(0.24)	(0.25)	(0.34)	(0.87)	(0.38)	(0.20)	(0.31)	(0.36)
Dividend-price ratio (Ann.)	-0.20	-1.45	-1.65	-0.53	-0.81	-9.04	-9.01	-8.82**	-8.17	-8.49
	(1.33)	(1.78)	(1.07)	(1.04)	(0.94)	(12.95)	(5.35)	(2.57)	(4.54)	(5.33)
GDP vol.						15.93	18.66*	7.21*	3.61	1.74
						(8.58)	(6.90)	(2.94)	(5.94)	(8.36)
Equity volatility (Ann.)						0.81	0.18	-0.16	-0.36	-0.38
						(0.82)	(0.50)	(0.24)	(0.35)	(0.49)
Leverage						-0.24	0.26	0.59	1.10*	0.97
						(1.76)	(0.93)	(0.36)	(0.45)	(0.62)
Bond volatility (Ann.)						11.95	5.08	13.55*	20.16*	21.49
						(20.14)	(8.51)	(5.25)	(8.63)	(12.15)
Bond-stock correlation						-14.79	-3.08	-7.60	-2.34	-5.91
						(20.37)	(9.68)	(5.73)	(12.60)	(13.28)
Business cycle and inflation shock variables (Logs)										
3-Year inflation shock	-0.83	-0.43	0.68	0.49	-0.14	-1.60	-1.21	-0.36	-1.02	-1.61
	(0.69)	(0.51)	(0.69)	(0.69)	(0.96)	(1.78)	(0.80)	(0.63)	(0.98)	(1.23)
3-Year real stock return	-0.03	0.13	0.26**	0.30**	0.31**	-0.04	0.13	0.23**	0.28**	0.27*
	(0.11)	(0.08)	(0.08)	(0.07)	(0.10)	(0.11)	(0.07)	(0.06)	(0.10)	(0.12)
3-Year GDP growth	3.66*	3.47**	3.97**	4.33**	3.44**	2.28	1.05	3.31**	3.71**	3.36
	(1.33)	(0.99)	(0.71)	(0.43)	(0.82)	(1.70)	(1.58)	(0.96)	(1.21)	(1.87)
3-Year change unemployment	4.47	5.95**	7.23**	7.13**	4.61**	-0.57	-0.76	4.74	4.72	3.38
	(3.21)	(2.01)	(1.75)	(1.25)	(1.35)	(3.89)	(3.87)	(2.43)	(3.23)	(3.45)
Quarterly inflation shock	-3.25	4.13	2.43	0.78	3.85	1.12	5.02	3.52	2.29	5.94
	(5.93)	(6.28)	(3.69)	(3.12)	(4.08)	(5.07)	(5.25)	(2.93)	(3.99)	(6.59)
Quarterly real stock return	0.76*	0.52	0.39*	0.34*	0.32	0.37	0.29	0.17	0.14	0.09
	(0.30)	(0.35)	(0.16)	(0.15)	(0.16)	(0.46)	(0.30)	(0.11)	(0.19)	(0.25)
Quarterly GDP growth	-0.64	-0.08	-2.55	-2.72	-4.13	-5.28	-1.94	-3.73*	-3.18	-5.02
	(2.32)	(1.91)	(1.52)	(2.38)	(2.50)	(4.69)	(3.12)	(1.33)	(2.44)	(3.04)
R^2	0.29	0.48	0.75	0.69	0.59	0.37	0.61	0.83	0.78	0.67

Table VIII: Predicting U.S. Corporate Bond Excess Returns (1969.Q1-2009.Q4)

We regress quarterly U.S. long-term corporate bond log returns in excess of long-term government bond log returns against lagged inflation volatility, the inflation-stock correlation, and control variables. Corporate and government bond return indices are from Ibbotson. For a lag horizon of n quarters, we report Newey-West standard errors with 16+n lags. * and ** denote significance at the 5% and 1% levels, respectively.

$$ret^{corp}_{US,t\to t+n} - ret^{gov}_{US,t\to t+n} \;=\; \lambda^0_{US} + \lambda^{\sigma^\pi}\sigma^\pi_{US,t} + \lambda^{\rho^\pi}\rho^\pi_{US,t} + \lambda^{\sigma^{eq}}\sigma^{eq}_{US,t} + \lambda^{DP} DP_{US,t} + \Lambda \times X_{US,t} + \eta_{US,t}$$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Horizon (Quarters)	1	4	12	20	1	4	12	20
Inflation risk								
Inflation volatility (Ann.)	18.07	-42.65	-187.92	98.86	-25.26	-74.42	-123.08	227.28
	(35.24)	(92.40)	(196.22)	(255.45)	(59.21)	(140.95)	(165.92)	(223.61)
Inflation-stock correlation	149.52**	349.56**	452.86*	370.62**	60.29	347.14**	466.53**	427.03**
	(53.11)	(126.05)	(206.14)	(140.50)	(66.92)	(69.35)	(123.23)	(130.39)
Real uncertainty and other credit risk variables								
Idiosyncratic vol. (Ann.)	3.70	14.98*	33.81**	36.10**	3.01	31.87**	19.24*	27.37**
	(2.99)	(5.86)	(7.14)	(9.89)	(3.40)	(7.84)	(9.70)	(5.91)
Dividend-price ratio (Ann.)	20.05	68.49*	162.45**	185.62*	67.40*	356.86**	-29.59	27.12
	(18.14)	(34.48)	(49.01)	(92.72)	(33.50)	(111.40)	(119.21)	(95.54)
GDP vol.					4.16	-44.68	-57.03	269.69
					(69.74)	(158.23)	(176.29)	(191.81)
Log T-bill					6.40	28.44*	17.24*	-2.18
					(6.02)	(13.65)	(8.69)	(11.06)
Log yield curve slope					-57.44**	-142.70**	25.86	-33.86
					(11.69)	(36.79)	(60.10)	(22.98)
Equity volatility (Ann.)					-115.98**	-197.68**	55.38	-34.75
					(27.74)	(61.15)	(56.69)	(47.21)
Leverage					6.68	-26.12	42.11**	43.69**
					(6.26)	(23.17)	(14.27)	(13.50)
Bond volatility (Ann.)					331.33**	-156.93	404.73**	-92.13
					(99.95)	(252.25)	(103.58)	(205.00)
Bond-stock correlation					-141.93	-333.09	-19.63	29.27
					(116.43)	(238.45)	(107.05)	(188.17)
Liquidity variables								
Treasury off-the-run spread					-295.37**	-185.49	89.73	1,031.13
					(102.73)	(325.84)	(346.55)	(711.30)
Eurodollar over T-bill					-60.71**	24.22	16.75	16.35
					(17.66)	(82.13)	(47.72)	(73.04)
Business cycle and inflation shock variables (Logs)								
3-Year inflation shock	-15.11	-18.46	-1.47	28.17	-35.82*	-22.30	-23.88	0.31
	(9.61)	(15.08)	(17.49)	(22.26)	(16.73)	(28.31)	(18.60)	(27.69)
3-Year real stock return	-0.57	-2.54	-3.51	3.86	-0.16	-1.57	-1.55	6.36*
	(0.68)	(1.77)	(2.30)	(3.10)	(1.07)	(1.39)	(2.81)	(2.61)
3-Year GDP growth	4.52	17.64	76.88*	154.60**	-5.87	21.35	34.14	30.21
	(6.92)	(25.11)	(29.75)	(32.14)	(11.31)	(48.94)	(47.98)	(56.15)
3-Year change unemploymen	38.24**	93.52	211.38**	305.93**	26.83	124.97	103.33	52.13
	(13.55)	(50.36)	(46.41)	(75.15)	(25.03)	(98.10)	(94.53)	(131.93)
Quarterly inflation shock	39.37	-119.96*	-170.78**	-176.81	61.54	-100.27**	-125.23**	-142.03
	(63.98)	(53.07)	(43.47)	(102.45)	(65.30)	(26.75)	(38.21)	(94.28)
Quarterly real stock return	1.72	-1.53	1.37	-4.67	1.22	-1.70	3.01	-4.88
	(3.13)	(2.74)	(4.22)	(6.35)	(3.43)	(2.54)	(4.69)	(5.51)
Quarterly GDP growth	-3.05	-20.94	-91.17	-77.22	12.50	-31.93	-80.04	-35.68
	(22.69)	(40.58)	(62.58)	(44.33)	(23.30)	(63.09)	(55.44)	(37.00)
R^2	0.14	0.32	0.52	0.50	0.28	0.49	0.64	0.63
Period	Full	Full	Full	Full	72.Q1-09.Q4	72.Q1-09.Q4	72.Q1-09.Q4	72.Q1-09.Q4

Table IX: Israeli Inflation-Indexed Credit Spreads and Inflation Risk (2000.Q1-2010.Q4)

We regress the spread of Israeli inflation-indexed corporate bond log yields over government bond log yields against inflation volatility, the inflation-stock correlation, and control variables. Israeli corporate bond yields reflect corporate bonds issued by non-financial firms with five to eleven years remaining to maturity. All corporate bonds are rated A- or higher by S&P Maalot or A3 or higher by Midroog. Maturity-matched inflation-indexed government bond yields are from the Bank of Israel. A detailed data description is available in Supplementary Appendix C.4. We report Newey-West standard errors with 4 lags in parentheses. * and ** denote significance at the 5% and 1% levels, respectively.

$$spread_{i,t} = \lambda_i^0 + \lambda^{\sigma^\pi} \sigma_{i,t}^\pi + \lambda^{\rho^\pi} \rho_{i,t}^\pi + \lambda^{\sigma^{eq}} \sigma_{i,t}^{eq} + \lambda^{DP} DP_{i,t} + \Lambda \times X_{i,t} + \eta_{i,t}$$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Inflation risk							
Inflation volatility (Ann.)		-127.00*	-1.14		-53.74	-61.14**	-110.86
		(52.09)	(66.19)		(56.89)	(20.13)	(56.86)
Inflation-stock correlation			267.43		178.27	-46.67	-171.35
			(147.59)		(112.28)	(55.41)	(130.31)
Real uncertainty and other control variables							
Equity volatility (Ann.)				4.48	5.83	-0.08	-3.00
				(5.36)	(4.95)	(1.66)	(4.50)
Dividend-price ratio (Ann.)				0.88	0.19	-0.03	-0.35*
				(0.73)	(0.40)	(0.07)	(0.14)
Italy-Germany 10 year gov. yield spread							3.80
							(1.99)
Business cycle and inflation shock variables (Logs)							
Quarterly inflation shock	-20.87	-31.13	-18.00	-29.58	-24.05	7.80	-25.28
	(28.45)	(30.83)	(24.71)	(29.85)	(26.95)	(6.90)	(21.97)
Quarterly real stock return	-3.48	-3.69	-3.79	-2.44	-3.70	0.18	-3.45
	(3.20)	(2.60)	(2.90)	(2.70)	(2.53)	(0.37)	(1.97)
R^2	0.08	0.32	0.42	0.19	0.45	0.53	0.60
Period	Full	Full	Full	Full	Full	00.Q1-07.Q4	Full